

# SIMULA

## Multimedia Training Courses on: Non Destructive Testing, Metallurgy, Corrosion & ...



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Update to March 2023



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# MULTIMEDIA TRAINING COURSES

## Non Destructive Testing (NDT) – release 5.0



### ULTRASONIC TESTING



### RADIOGRAPHIC TESTING



### MAGNETIC PARTICLE TESTING



### LIQUID PENETRANT TESTING



### VISUAL TESTING



### EDDY CURRENT TESTING

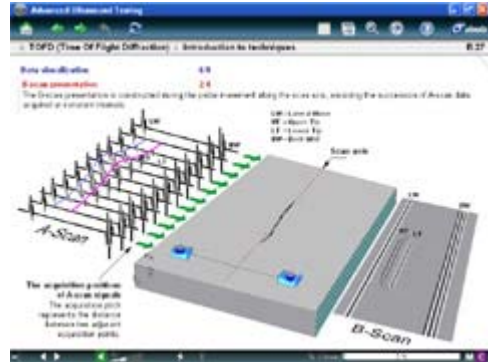
## ADVANCED ULTRASONIC TESTING



### PHASED ARRAY



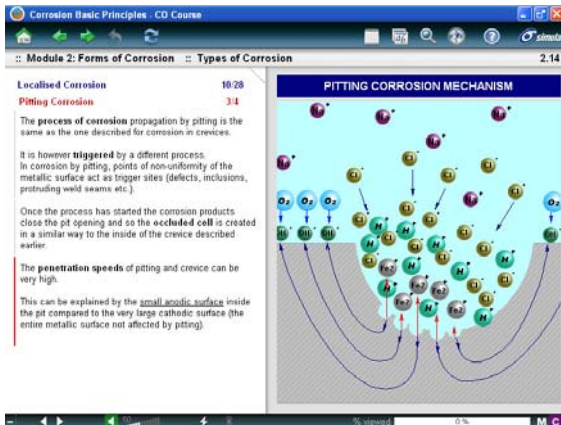
### TOFD – Time of Flight Diffraction



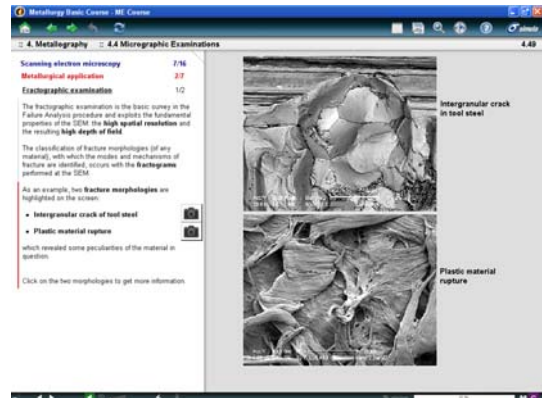
## Corrosion and Metallurgy - release 5.0



### CORROSION BASIC PRINCIPLES



### METALLURGY BASIC COURSE



### >> FEATURES

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## FEATURES

The courses have been designed with the idea of facilitating access to contents and their comprehension.

The attempt to achieve these objectives has led us to develop a set of tools for rapid navigation between sections of the course (index, map, route, search, bookmark) and to use different ways of presenting information (text, voice, video clips, self-assessment tests). The list of some of these features is given below.

- Voice guide
- Interactive text
- Interactive animations
- Video clips
- Theory consolidation
- Intermediate self-assessment tests
- Final tests
- Glossary and Text search
- Display of path completed
- Bookmarking

### Others features:

- Page size 1024 x 768 px.
- Browser-style interface, for a more functional and intuitive use.



- New tools, including the "User Notes" to record notes and pictures of personal experiences.
- Management of animation sequences, for a more simple and rapid comprehension.



- Integration of new topics.

### AVAILABLE LANGUAGES

The NDT Training Courses are available in the following languages:



**English (UT, RT, MT, PT, ET, VT, PA-TOFD, CO, ME)**

**Italian (UT, RT, MT, PT, ET, VT, PA-TOFD, CO, ME)**

**Spanish (UT, RT, MT, PT, VT, PA-TOFD)**

**French (RT, MT, PT)**

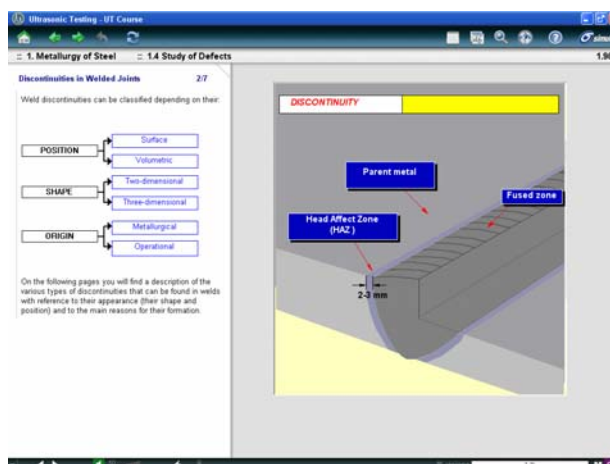
**German (PT)**

**China (UT)**

## UT - ULTRASONIC TESTING

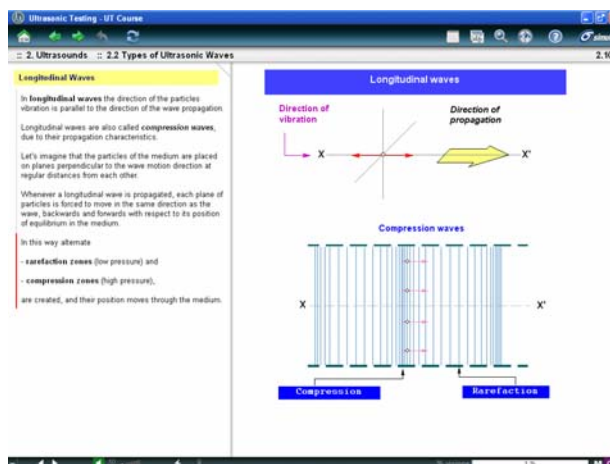
### 1. METALLURGY OF STEEL

- 1.1 Production of Carbon Steels
- 1.2 Heat Treatments
- 1.3 Mechanical Tests
- 1.4 Types of Fracture
- 1.5 Steel Products
- 1.6 Study of Defects
- Self-evaluation Tests



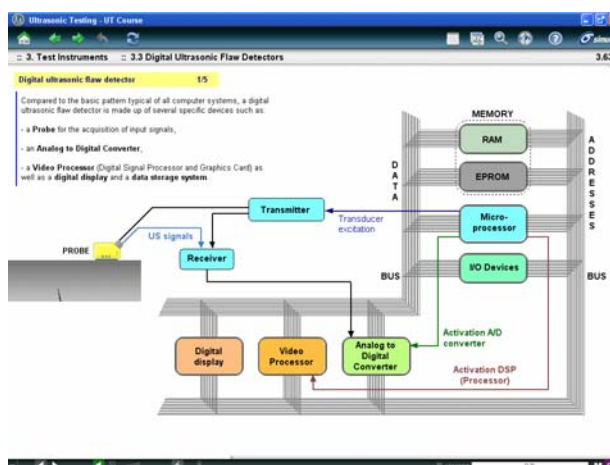
### 2. ULTRASOUNDS

- 2.1 Introduction
- 2.2 Types of Ultrasonic Waves
- 2.3 Parameters of Waves
- 2.4 Ultrasound Propagation
- Self-evaluation Tests



### 3. TEST INSTRUMENTS

- 3.1 Transducers
- 3.2 Ultrasound Equipment
- 3.3 Digital Ultrasound Equipment
- Self-evaluation Tests



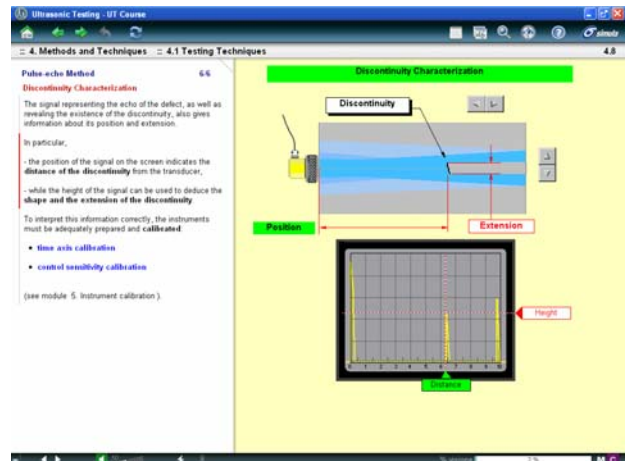
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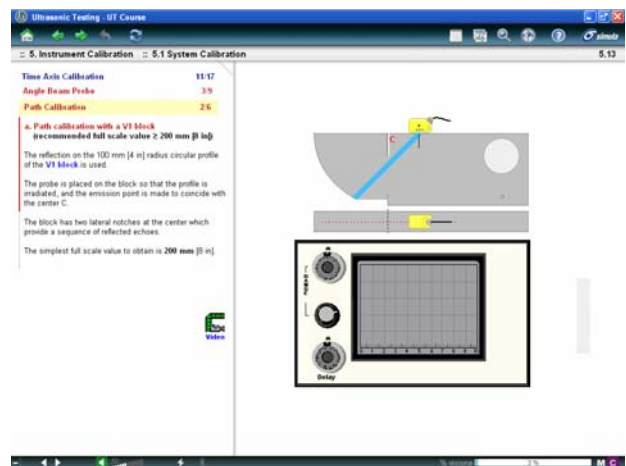
## 4. METHODS AND TECHNIQUES

- 4.1 Testing Methods
- 4.2 Testing Techniques
- Self-evaluation Tests



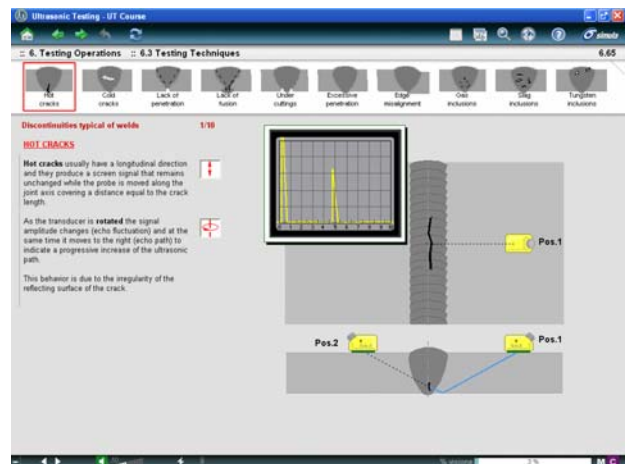
## 5. INSTRUMENT CALIBRATION

- 5.1 System Calibration
- 5.2 Periodic Calibration Check
- 5.3 Characterization of Probes
- 5.4 Reference Blocks
- Self-evaluation Tests



## 6. TESTING OPERATIONS

- 6.1 Piece Examination and Equipment Selection
- 6.2 Testing Procedure
- 6.3 Testing Techniques
- 6.4 Evaluation of Reflectors
- Self-evaluation Tests



**FINAL TEST: Over 700 final tests.**

**NORMS: Over 100 norm references**

**Sim SCAN: UT simulator**

## ULTRASONIC TESTING: DETAILED INDEX

### 1. METALLURGY OF STEEL (>> UT)

#### 1.1 Production of Carbon Steels

- Manufacturing Process
- Iron-Carbon Diagram
- Addition of Elements
- Classification of Steels
- Designation of Steels
- Stainless Steels

#### 1.2 Heat Treatments

- Full Annealing
- Normalisation
- Hardening
- Tempering
- Thermo-chemical Treatments:  
Cementation, Nitriding

#### 1.3 Mechanical Tests

- Tensile Test
- Hardness Test
- Resilience Test
- Creep Test

#### 1.4 Types of Fracture

- Tough Fracture
- Brittle Fractures
- Fatigue Fractures

#### 1.5 Steel Products

- Classification of Products
- Forged Pieces, Castings
- Rolled Plates, Pipes
- Welded Joints

#### 1.6 Study of Defects

- Discontinuities in Steel
- Discontinuities in Forged Pieces
- Discontinuities in Castings
- Discontinuities in Rolled Plates
- Discontinuities in Pipes
- Discontinuities in Welded Joints

#### 1.7 Self-evaluation Tests

- Heat Treatments
- Mechanical Tests
- Types of Fractures
- Production of Carbon Steels
- Study of Defects

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## 2. ULTRASOUNDS ([>> UT](#))

### 2.1 Introduction

- Generality of Waves
- Wave Propagation
- Wave Parameters
- Wave Front
- Ultrasonic Waves

### 2.3 Parameters of Waves

- Propagation Velocity
- Frequency
- Wavelength
- Acoustic Impedance
- Sound Pressure
- Acoustic Intensity

### 2.5 Self-evaluation Tests

- Introduction to ultrasounds
- Types of ultrasonic waves
- Parameters of waves
- Ultrasound propagation

### 2.2 Types of Ultrasonic Waves

- Longitudinal Waves
- Transverse Waves
- Surface Waves
- Lamb Waves

### 2.4 Ultrasound Propagation

- Huygens' Principle
- Irradiation Field
- Beam Attenuation
- Laws of Reflection
  - Reflection on Thin Films
- Laws of Refraction
  - Snell's Law
  - Critical Angles
  - Beams of Transverse Waves
- Scattering
- Diffraction

## 3. TEST INSTRUMENTS ([>> UT](#))

### 3.1 Transducers

- Introduction to Transducers
- Piezoelectric Transducers
- Electrostrictive Transducers
- Characteristics of Materials
- Transducer Excitation
- Types of Ultrasonic Transducers
  - Straight Beam Transducer
  - Angle Beam Transducer
  - Twin Crystal Contact

Transducer

- Wheel-type Transducers
- Water-column Transducers
- Immersion Transducers

### 3.3 Digital Ultrasonic flaw detectors

- Analog and digital systems
- Architecture of a digital system
- Digital ultrasonic flaw detector
- Components

### 3.2 Ultrasound Equipment

- Introduction
- Cathodic Ray Tube
- Synchronizer
- Transmitter
- Sweep Generator
- Delay Circuit
- Receiver
- Additional Equipment
- Echo Presentation

### 3.4 Self-evaluation Tests

- Transducers
- Ultrasonic equipment
- Digital Ultrasonic flaw detectors



- A/D Converter
- Digital Signal Processor
- Digital display
- Features
  - Data storage
  - Multi-channel operation mode
  - Interface and control panel
- Digital flaw detector simulator
- Examples of digital flaw detector

## 4. METHODS AND TECHNIQUES (>> UT)

### 4.1 Testing Methods

- Pulse-echo Method
  - Basic Signals
  - Presence of a Discontinuity
  - Typical Reflection Cases
  - Discontinuity Characterization
- Resonance Method
  - Resonance Frequency
  - Depth of a Discontinuity
- Through-Transmission Method
  - with Transmission
  - with Reflection
  - with Conduction

### 4.2 Testing Techniques

- Contact Technique
  - Examination of the Surface
  - Coupling Media
- Immersion Technique
  - Straight Beam Testing
  - Angled Beam Testing
- Comparison Between Techniques

### 4.3 Self-evaluation Tests

- Testing methods
- Testing techniques

## 5. INSTRUMENT CALIBRATION (>> UT)

### 5.1 System Calibration

- Time Axis Calibration
  - Delay Calibration
  - Longitudinal Beam Probe
  - Angle Beam Probe
- Sensitivity Calibration
- Construction of a DAC curve
  - Procedure
  - Discontinuities Evaluation
  - Distance-Amplitude Diagram
  - Examples of the DAC curve
- DGS Diagrams
  - Universal Diagrams
  - Sizing Discontinuities
  - Equivalent Diameter Calculation

### 5.2 Periodic Calibration Check

- Periodic Calibration Checks
- Horizontal Linearity Check
- Vertical Linearity Check
  - Check the Echoes Heights Ratio
  - Check the Surface-Amplitude Ratio
- Amplitude Control Linearity

### 5.3 Characterization of Ultrasonic Transducers

### 5.4 Reference Blocks

- Reference Blocks

#### *Characterization of Longitudinal Probes*

- Ultrasonic Beam Profile
- Alignment of the Beam

#### *Characterization of Angle Probes*

- Emission Point
- Emission Angle
- Alignment of the Beam
- Profile of the Ultrasonic Beam
  - Profile on the Vertical Plane
  - Profile on the Horizontal Plane
- Amplification Reserve
- Transverse Resolving Power

- SDH Block, 1OW Block
- Steel Block 25 x 150 x 250 mm
- IIW V1 Block, IIW V2 Block
- ASTM Blocks
- Other Types of Blocks

### **5.5 Self-evaluation Tests**

- System calibration
- Periodical calibration check
- Characterization of ultrasonic transducers

## **6. TESTING OPERATIONS (>> UT)**

### **6.1 Piece Examination and Equipment Selection**

- Examination of the Piece
- Selection of the Equipment
  - Ultrasound Equipment
  - Probe
  - Coupling Medium

### **6.2 Testing procedure**

- Surface Preparation
- Calibration of the Equipment
- Non-welded Components
  - Tests with Longitudinal Probes
  - Tests with Angle Probes
- Tests on Welds
- Norms and Standards

### **6.3 Testing Techniques**

- Tests on Rolled Plates
- Tests on Forged Pieces
  - Tests with Longitudinal Beam Probes
  - Tests with Angle Beam Probes
- Tests on Castings
- Tests on Seamless Pipes
  - Longitudinal Discontinuities
  - Transverse Discontinuities
- Tests on Welded Joints
  - Longitudinal Discontinuities in Butt Joints
  - Transverse Discontinuities in Butt Joints
  - Nature of the Discontinuity
  - Discontinuities Typical of Welds
  - Detection of Discontinuities in Tee Joints

### **6.4 Evaluation of reflectors**

- False Indications
- Locate the Defect
  - Longitudinal Beam Scanning
  - Angled Beam Scanning
- Sizing the Defects
  - System for Measuring Reflected Intensity
  - Reflector Outline Definition System

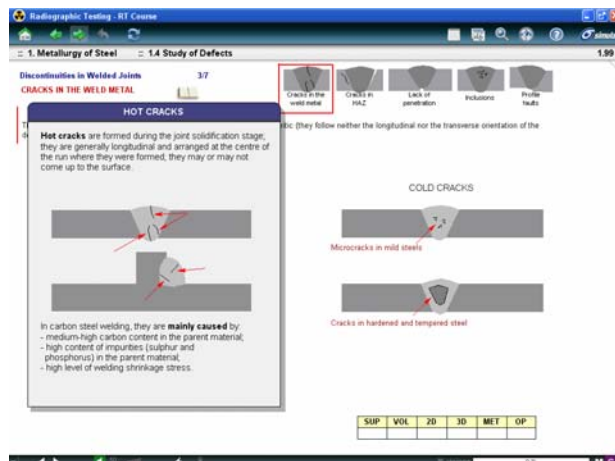
### **6.5 Self-evaluation Tests**

- Testing procedure
- Testing techniques
- Evaluation of reflectors

# RT - RADIOGRAPHIC TESTING

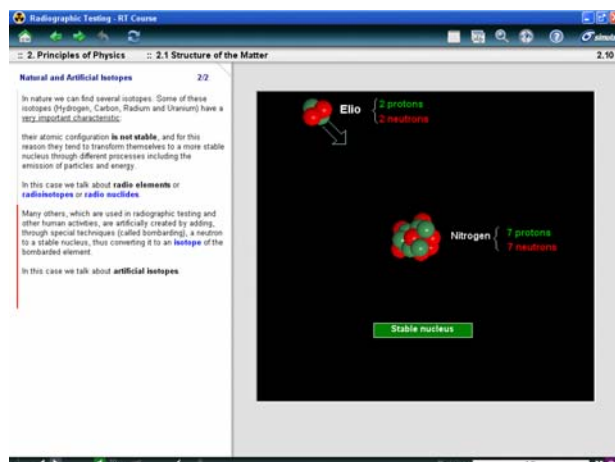
## 1. METALLURGY OF STEEL

- 1.1 Production of Carbon Steels
- 1.2 Heat Treatments
- 1.3 Mechanical Tests
- 1.4 Types of Fracture
- 1.5 Steel Products
- 1.6 Study of Defects
- Self-evaluation Tests



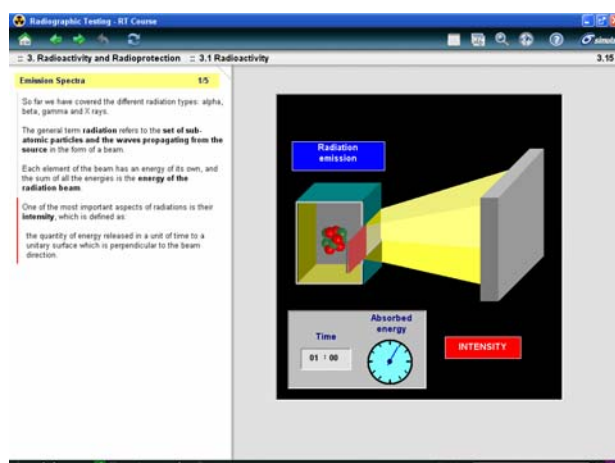
## 2. PRINCIPLES OF PHYSICS

- 2.1 Structure of the Matter
- 2.2 Electromagnetic Waves
- 2.3 Electricity
- Self Evaluation Test



## 3. RADIOACTIVITY AND RADIOPROTECTION

- 3.1 Radioactivity
- 3.2 Radioprotection
- Self Evaluation Test



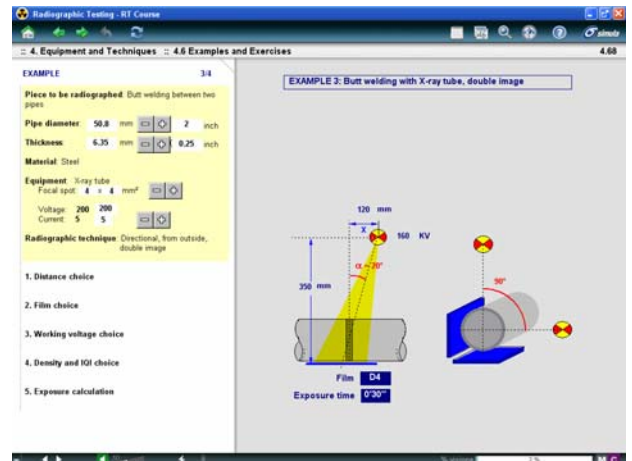
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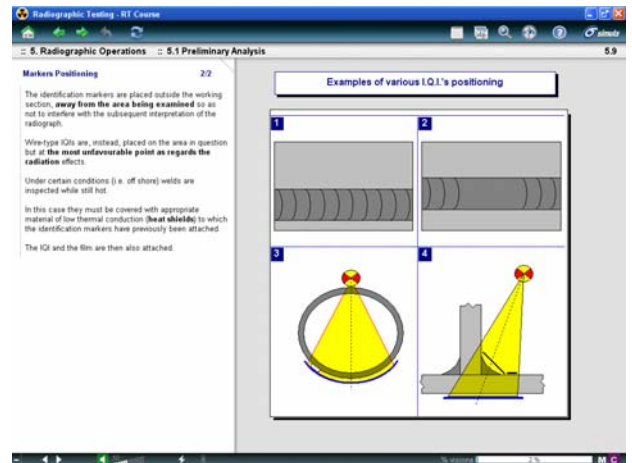
## 4. EQUIPMENT AND TECHNIQUES

- 4.1 Radiation Generators
- 4.2 Films
- 4.3 Image Quality
- 4.4 Exposure Factors
- 4.5 Radiographic Techniques
- 4.6 Examples and Exercises
- Self Evaluation Test



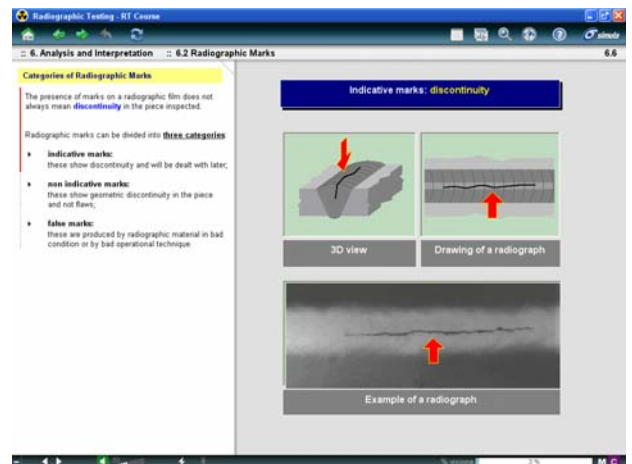
## 5. RADIOGRAPHIC OPERATIONS

- 5.1 Preliminary Analysis
- 5.2 Radiographic Inspection
- 5.3 Developing
- Self Evaluation Test



## 6. ANALYSIS AND INTERPRETATION

- 6.1 Analysis Instruments
- 6.2 Radiographic Marks
- 6.3 Radiograph Reading
- Self Evaluation Test



## VIDEOTHEQUE

**FINAL TEST: Over 600 final tests.**

**NORMS: Over 100 norm references**

## RADIOGRAPHIC TESTING: DETAILED INDEX

### **1. METALLURGY OF STEEL ([>> RT](#))**

#### **1.1 Production of Carbon Steels**

- Manufacturing Process
- Iron-Carbon Diagram
- Addition of Elements
- Classification of Steels
- Designation of Steels
- Stainless Steels

#### **1.2 Heat Treatments**

- Full Annealing
- Normalisation
- Hardening
- Tempering
- Thermo-chemical Treatments:  
Cementation / Nitriding

#### **1.3 Mechanical Tests**

- Tensile Test
- Hardness Test
- Resilience Test
- Creep Test

#### **1.4 Types of Fracture**

- Tough Fracture
- Brittle Fractures
- Fatigue Fractures

#### **1.5 Steel Products**

- Classification of Products
- Forged Pieces, Castings
- Rolled Plates, Pipes
- Welded Joints

#### **1.6 Study of Defects**

- Discontinuities in Steel
- Discontinuities in Forged Pieces
- Discontinuities in Castings
- Discontinuities in Rolled Plates
- Discontinuities in Pipes
- Discontinuities in Welded Joints

#### **1.7 Self-evaluation Tests**

- Heat Treatments
- Mechanical Tests
- Types of Fractures
- Production of Carbon Steels
- Study of Defects

### **2. PRINCIPLES OF PHYSICS ([>> RT](#))**

#### **2.1 Structure of the Matter**

- Structure of the Atom
- Natural and Artificial Isotopes
- Structure of Metals

#### **2.2 Electromagnetic Waves**

- Wave Concept
- Wave Parameters
- Electromagnetic Waves

#### **2.3 Electricity**

- Electrical Charge
- Electrical Field
- Potential Difference
- Electrical Current
- Resistance
- Joule Effect
- Transformer

#### **2.4 Self Evaluation Test**

- Structure of the matter
- Electromagnetic waves
- Electricity

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### 3. RADIOACTIVITY AND RADIOPROTECTION (>> RT)

#### 3.1 Radioactivity

- Radiations
- Decay
- X-rays
- Emission Spectra
- Penetration Power
- Ionization
- Absorption
- Unit of Measure

#### 3.2 Radioprotection

- Meaning of Dose
- Biological Effects of Radiation
- Dose Limits
- Radiation Protection
- Radiation Measurement

#### 3.3 Self Evaluation Test

- Radioactivity
- Radioprotection

### 4. EQUIPMENT AND TECHNIQUES (>> RT)

#### 4.1 Radiation Generators

- X-ray Equipment
- Gamma Ray Equipment
- Crawler-Fitted X and Gamma Sources

#### 4.2 Films

- Film
- Sensitometric Curves
- Types of Films
- Film Choice
- Intensifying Screens
- Comparison Between X and Gamma Rays

#### 4.3 Image Quality

- Sensitivity
- Image Quality Factors
- Image Quality Indicators
- Synthesis of Image Quality Parameters

#### 4.4 Exposure Factors

- Exposure Diagrams
- Correction Factors
- Equivalent Radiographs
- Slide Rule for Gamma-Rays

#### 4.5 Radiographic Techniques

- Weld Testing
- Casting and Forging Examination

#### 4.6 Examples and Exercises

- EXAMPLES
- EXERCISES

#### 4.7 Self Evaluation Test

- Radiation generators
- Films
- Image quality
- Exposure factors
- Radiographic techniques

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## 5. RADIOGRAPHIC OPERATIONS ([>> RT](#))

### 5.1 Preliminary Analysis

- Study of the Test Piece
- Films Preparation
- Markers Positioning
- Film Positioning
- Source Positioning
- Shield Positioning
- Cordon off the Controlled Area
- Filmed Synthesis of Preliminary

Analysis

### 5.3 Developing

- Film Preparation
- Developing Process
- Equipment for Manual Developing
- Equipment for Automatic Developing
- Filmed Synthesis of the Developing

### 5.2 Radiographic Inspection

- Setting of the X-ray Parameters
- Preparation of a Gamma-ray  
Equipment
- Operations to Carry Out a  
Radiograph
- Safety During the Exposure
- Safety After the Exposure

### 5.4 Self Evaluation Test

- Radiographic inspection
- Developing

## 6. ANALYSIS AND INTERPRETATION ([>> RT](#))

### 6.1 Analysis Instruments

- Negatoscopes
- Densitometers

### 6.2 Radiographic Marks

- Categories of Radiographic Marks
- False Marks
- Imperfect Radiographs
- Indicative Marks

### 6.3 Radiograph Reading

- Conditions of the Radiograph Reading
- General Interpretation Aspects
- Visibility of the Defects
- Acceptability Standard
- Radiograph Archive
- Reading Exercise

### 6.4 Self Evaluation Test

- Analysis instruments
- Radiographic marks
- Radiograph reading

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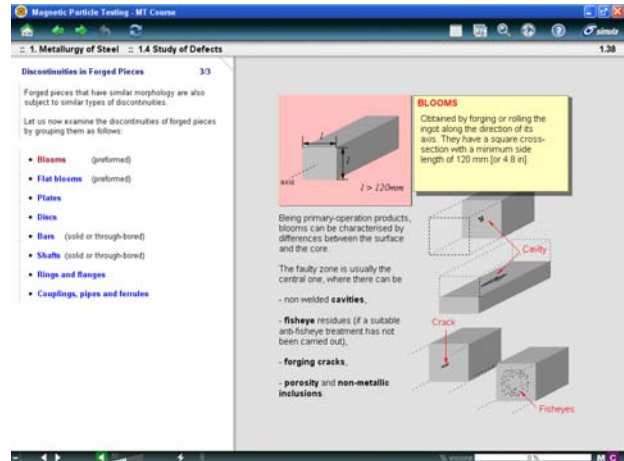
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# MT - MAGNETIC PARTICLE TESTING

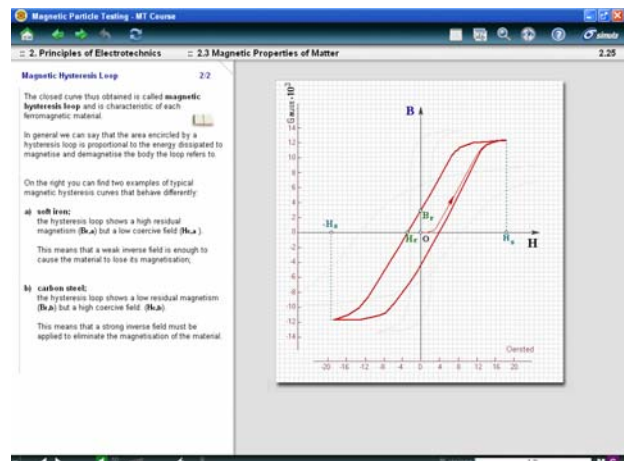
## 1. METALLURGY OF STEEL

- 1.1 Steel
- 1.2 Heat Treatments
- 1.3 Production of Carbon Steels
- 1.4 Study of Defects
- Self-evaluation test



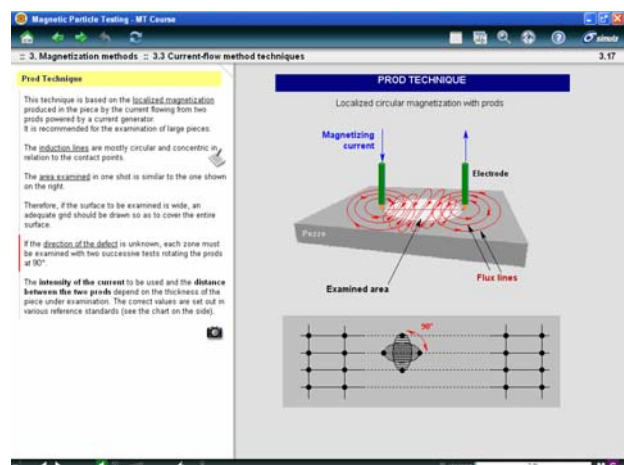
## 2. ELECTROTECHNICS PRINCIPLES

- 2.1 Natural magnetism
- 2.2 Electricity and magnetism
- 2.3 Magnetic properties of matter
- 2.4 Electric current
- 2.5 Standard Units
- Self-evaluation test



## 3. MAGNETIZATION METHODS

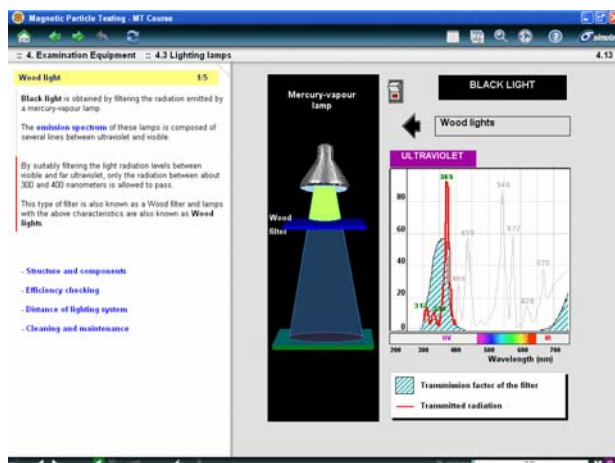
- 3.1 Examination principle
- 3.2 Criteria for the examination
- 3.3 Current-flow method techniques
- 3.4 Magnetic-field method techniques
- 3.5 Magnetizing currents
- Self-evaluation test





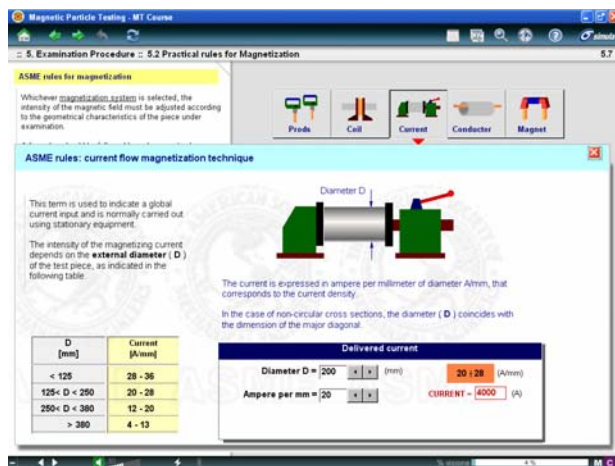
#### 4. EXAMINATION EQUIPMENT

- 4.1 Magnetic particles
- 4.2 Characteristic of the particles
- 4.3 Lighting lamps
- 4.4 Magnetization Equipment
- Self-evaluation test



#### 5. EXAMINATION PROCEDURE AND RESULTS EVALUATION

- 5.1 Preliminary activities
- 5.2 Magnetization rules
- 5.3 Magnetic field checking
- 5.4 Sequence of operations
- 5.5 Test results evaluation
- Self-evaluation test



#### VIDEOTHEQUE

**FINAL TEST: Over 600 final tests.**

**NORMS: Over 50 norm references**

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## MAGNETIC PARTICLE TESTING: DETAILED INDEX

### **1. METALLURGY OF STEEL ([>> MT](#))**

#### **1.1 Steel**

- Introduction
- Components
- Solidification
- Iron-Carbon Diagram

#### **1.3 Production of Carbon Steels**

- Manufacturing Process
- Classification of Products
  - Forged pieces
  - Castings
  - Rolled plates
  - Pipes
  - Welded joints

#### **1.5 Self-evaluation test**

- Steel
- Heat Treatments
- Production of Carbon Steels
- Study of Defects

#### **1.2 Heat Treatments**

- Introduction
- Annealing
- Normalization

#### **1.4 Study of Defects**

- Discontinuities in steel
- Discontinuities in forged pieces
- Discontinuities in castings
- Discontinuities in rolled plates
- Discontinuities in pipes
- Discontinuities in welded joints

### **2. ELECTROTECHNICS PRINCIPLES ([>> MT](#))**

#### **2.1 Natural magnetism**

- Magnets
- Magnetic Field

#### **2.2 Electricity and magnetism**

- Introduction
- Rectilinear conductor
- Loop
- Coil
- Solenoid
- Toroidal coil
- Magnetomotive force

#### **2.3 Magnetic properties of matter**

- Ferromagnetism
- Magnetic Induction
- Magnetic hysteresis loop
- Magnetic flux

#### **2.4 Electric current**

- Electric current definition
- Kinds of current
- Alternating current parameters
- Measuring instruments

#### **Standard Units**

#### **2.5 Self-evaluation test**

- Electricity and magnetism
- Magnetic properties of matter
- Electric current

### 3. MAGNETIZATION METHODS ([>> MT](#))

#### 3.1 Examination principle

- Magnetic particle examination
- Advantages and limitations

#### 3.2 Criteria for the examination

- Examination methods
- Magnetization methods
- Types of magnetization

#### 3.3 Current-flow method techniques

- Current-flow methods
- Electrodes at either end of the piece
- Prod technique

#### 3.4 Magnetic-field method techniques

- Magnetic-field method techniques
- Central conductor
- Yoke technique
- Coil
- Through-cable technique

#### 3.5 Magnetizing currents

- Magnetizing currents
- Direct current
- Alternating current
- Rectified current
- Current values

#### 3.6 Self-evaluation test

- Examination principle
- Method techniques
- Magnetizing currents

### 4. EXAMINATION EQUIPMENT ([>> MT](#))

#### 4.1 Magnetic particles

- Types of examination medium
- Dry examination medium
- Wet examination medium
- Examination medium with contrast paint

#### 4.2 Characteristic of the particles

- Types of powders
- Efficiency of powders
- Checking the efficiency of powders

#### 4.3 Lighting lamps

- Light classification
- Wood light
  - Structure and components
  - Efficiency checking
  - Distance of lighting system
  - Cleaning and maintenance

#### 4.4 Magnetization Equipment

- Equipment classification
- Stationary magnetic-particle inspection unit
- Generator for prod examination
- Portable magnets
- Portable electromagnets
- Efficiency of the equipment

#### 4.5 Self-evaluation test

- Magnetic particles
- Lighting lamps
- Magnetization equipment

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## 5. EXAMINATION PROCEDURE AND RESULTS EVALUATION (>> MT)

### 5.1 Preliminary activities

- Test piece inspection
- Standard References

### 5.2 Magnetization rules

- ASME rules

### 5.3 Magnetic field checking

- Optimum induction level
- Instruments for the checking of magnetizing field
  - ASME probe
  - Berthold's probe
  - Reference block
  - Gauss meter

### 5.4 Sequence of operations

- Sequence of operations
- Step 1: Surface preparation
- Step 2: Checking for residual fields
- Step 3: Magnetization and spraying
- Step 4: Visual inspection
- Step 5: Demagnetization
- Step 6: Protective treatment

### 5.5 Test results evaluation

- Detecting a discontinuity
- Types of indications
- Types of discontinuities

### 5.6 Self-evaluation test

- Practical rules for magnetization
- Checking the magnetizing field
- Sequence of operations
- Evaluation of test results

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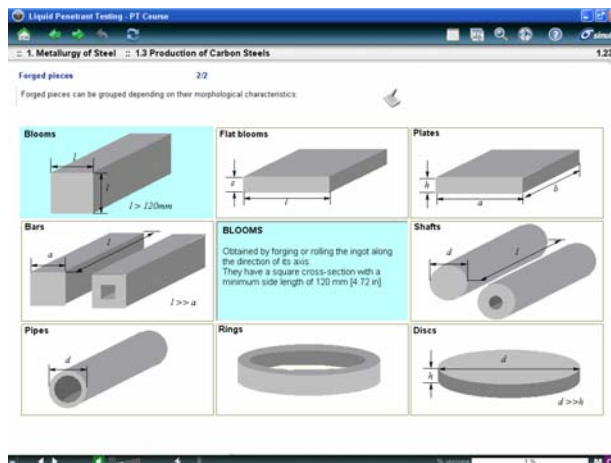
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## PT - LIQUID PENETRANT TESTING

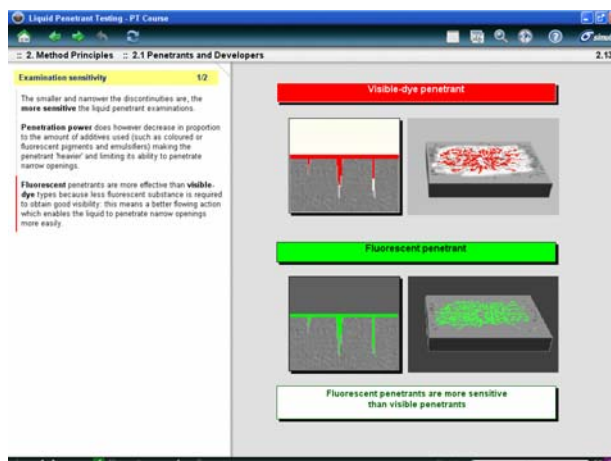
### 1. METALLURGY OF STEEL

- 1.1 Steel
- 1.2 Heat Treatments
- 1.3 Production of Carbon Steels
- 1.4 Study of Defects
- Self-evaluation test



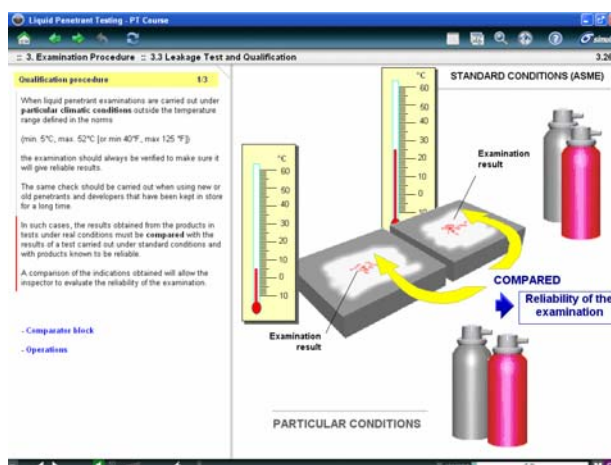
### 2. METHOD PRINCIPLES

- 2.1 Penetrants and Developers
- 2.2 Light Sources
- Self-Evaluation Test



### 3. EXAMINATION PROCEDURE

- 3.1 Preliminary Activities
- 3.2 Examination Operations
- 3.3 Tests
- Self-Evaluation Test



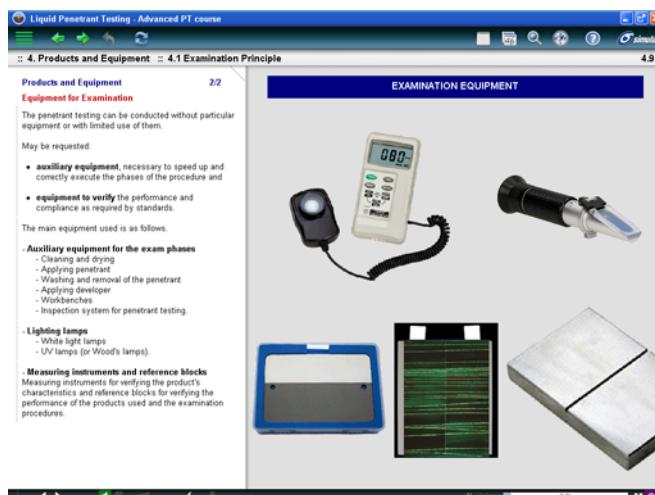
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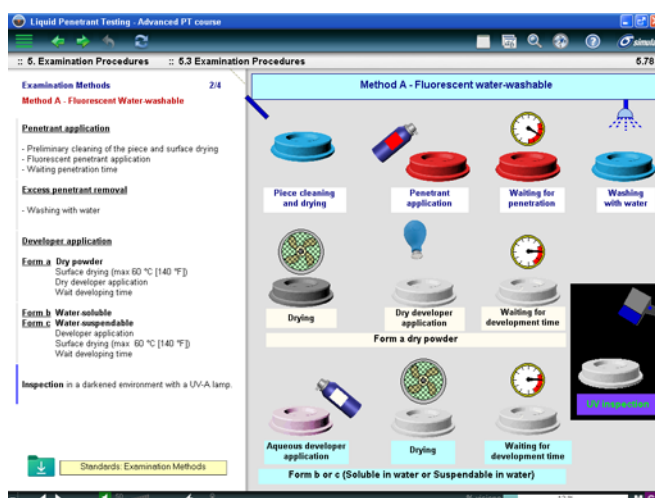
## 4. PRODUCT AND EQUIPMENT

- 4.1 Examination Principle
- 4.2 Liquids Penetrant
- 4.3 Developers
- 4.4 Solvents and Emulsifiers
- 4.5 Examination Equipment
- 4.6 Performance and Features
- Self-Evaluation Test



## 5. EXAMINATION PROCEDURE

- 5.1 Preliminary Activities
- 5.2 Examination Phases
- 5.3 Examination Procedures
- 5.4 Detectable Discontinuities
- 5.5 Qualification and Leak Test
- Self-Evaluation Test



## VIDEOTHEQUE

**FINAL TEST: Over 500 final tests.**

**NORMS: Over 40 norm references**

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## LIQUID PENETRANT TESTING: DETAILED CONTENTS

### 1. METALLURGY OF STEEL ([>> PT](#))

#### 1.1 Steel

- Introduction
- Components
- Solidification
- Iron-Carbon Diagram

#### 1.2 Heat Treatments

- Introduction
- Annealing
- Normalization

#### 1.3 Production of Carbon Steels

- Manufacturing Process
- Classification of Products
  - Forged pieces
  - Castings
  - Rolled plates
  - Pipes
  - Welded joints

#### 1.4 Study of Defects

- Discontinuities in steel
- Discontinuities in forged pieces
- Discontinuities in castings
- Discontinuities in rolled plates
- Discontinuities in pipes
- Discontinuities in welded joints

#### 1.5 Self-evaluation test

- Steel
- Heat Treatments
- Production of Carbon Steels
- Study of Defects

### 2. METHOD PRINCIPLES ([>> PT](#))

#### 2.1 Penetrants and Developers

- Examination Principle
- Penetrants Classification
- Chemical Characteristics
- Physical Properties
- Other Properties
- Examination Sensitivity
- Developers
- Developers Classification
- Synthesis of the Characteristics

#### 2.2 Light Sources

- Classification
- Black Light Lamp
  - Structure and components
  - Efficiency Verification
  - Distance of lighting system
  - Cleaning and Maintenance

#### 2.3 Self-Evaluation Test

- Penetrants and developers
- Light sources

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### 3. EXAMINATION PROCEDURE ([>> PT](#))

#### 3.1 Preliminary Activities

- Test piece inspection
- Standards References
- Selection of method and type of liquid

#### 3.2 Examination Operations

- Introduction
- STEP 1: Surface Cleaning
- STEP 2: Penetrant Application
- STEP 3: Dwell Time
- STEP 4: Penetrant Removal
- STEP 5: Developer Application
- STEP 6: Evaluation of the Indications
- Synthesis of Operation

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- Leakage Test
- Procedure Qualification
  - Comparator block
  - Operations

#### 3.4 Self-Evaluation Test

- Examination operations
- Tests

### 4. PRODUCT AND EQUIPMENT ([>> PT](#))

#### 4.1 Examination Principle

- Examination Principle
- Detectable Defects
- Types of Materials and Applications
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- Limitations of Method
- Products for Examination
- Equipment for Examination

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- **Introduction**
- **Types of Penetrants**
  - Fluorescent Penetrants
  - Color Contrast Penetrants
  - Combined Penetrants
  - Penetrants for Special Applications
- **Penetrants Classification**
  - Water Washable Penetrants
  - Solvent Removable Penetrants
  - Post-Emulsification Penetrants
  - Examination Methods
  - Examination Sensitivity
- **Characteristics and Properties**
  - Characteristics of Penetrants
  - Physical and Chemical Properties
  - Other Properties

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- **Developers Classification**
- **Developers Forms**
  - Dry Developers (Form a)

#### 4.4 Solvents and Emulsifiers

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- **Solvents**
  - Types of Solvents



- Wet Developers (Forms b, c, d, e)
  - Aqueous Developers (Form b)
  - Aqueous Developers (Form c)
  - Non-aqueous Developer (Form d, e)
  - Other Forms of Developers (Form f)
  
  - Developer Application
  - Developer Composition
  - Developer Characteristics
  - Advantages / Disadvantages of Developers
  - Synthesis of the Characteristics
- Use of Solvents
  
  - **Emulsifiers**
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  - Lipophilic Emulsifier (oil-based)
  - Hydrophilic Emulsifier (water-based)
  - Emulsifiers Comparison
  
  - **Emulsifier Application**
  - Preparation
  - Application Mode
  
  - Emulsification Time
  - Washing and Complete Removal Control
  - Emulsifiers Characteristics

#### 4.5 Examination Equipment

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- Black Light Lamp
- UV Lamp Types
- Mercury Vapor UV Lamps
- LED UV Lamps
- Cleaning and Maintenance
- **Measuring Instruments**
- Photometer
- UV-A Radiometer
- Refractometer
- Photo Fluorimeter
- **Reference Blocks**
- EN ISO Blocks (Type 1 and 2)
- TAM Panel
- Comparator Block
- Comparator Rules
- **Penetrant Test Kit**
- **Inspection Systems**
- Types of plant
- Stations of a plant
- Plant configuration

#### 4.6 Performance and Features

- **Performance Check**
- Removability check
- Sensitivity evaluation
- Contamination and degradation check
- Color Dye and fluorescence check
  
- **Features Check**
- Penetrant features check
- Developer features check

#### Self-Evaluation Test

- Examination Principle
- Penetrants and Developers
- Solvents and Emulsifiers
- Examination Equipment
- Performance and Features Check

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## 5. EXAMINATION PROCEDURE ([>> PT](#))

### 5.1 Preliminary Activities

- Test Piece Inspection
- Choice Method and Penetrant
- Standards References
- Written Procedure

### 5.2 Examination Phases

- Introduction
- STEP 1: Surface Cleaning
- STEP 2: Penetrant Application
- STEP 3: Penetration (Dwell) Time
- STEP 4: Removing Excess Penetrant
- STEP 5: Developer Application
- STEP 6: Inspection
- Post Cleaning
- Operations Synthesis

### 5.3 Examination Procedures

- **Examination procedures**
  - Examination with color contrast penetrants
  - Examination with fluorescent penetrants
  - Examination with water-washable penetrants
  - Examination with solvent removable penetrants
  - Examination with post-emulsifiable penetrants
- **Examination Methods**
  - Method A - Water Washable Fluorescents
  - Method B and D - Post-emulsifiable Fluorescents
  - Method C - Solvent Removable
- **Safety Standards**

### 5.4 Detectable Discontinuities

- Detectable Discontinuities
- Main Discontinuities

### 5.5 Qualification and Leak Test

- **Qualification Procedure**
  - Comparator Block
  - Operations
- **Leak Test**
- **Examination at Nonstandard Temperatures**
  - Examination at Low Temperatures
  - Examination at High Temperatures

### 5.6 Self-Evaluation Test

- Preliminary Activities
- Examination Operations
- Examination Procedures
- Detectable Discontinuities
- Qualification and Leak Test

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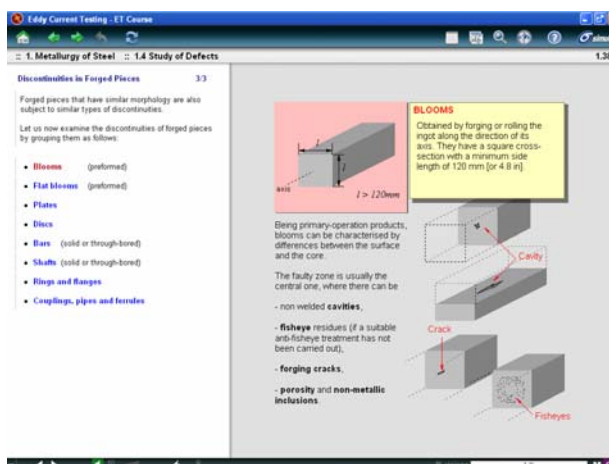
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## ET - EDDY CURRENT TESTING

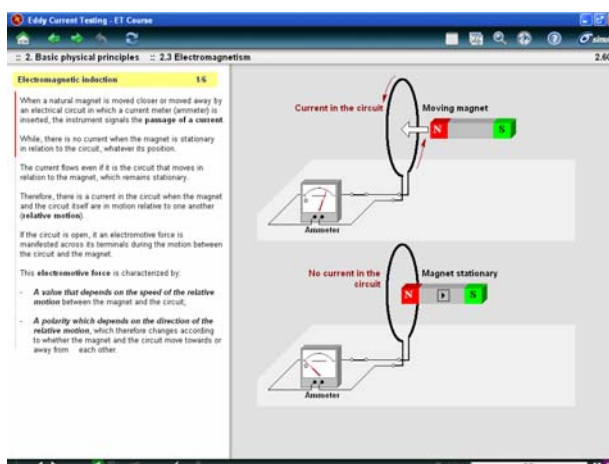
### 1. METALLURGY OF STEEL

- 1.1 Steel
- 1.2 Heat Treatments
- 1.3 Production of Carbon Steels
- 1.4 Study of Defects
- Self-evaluation Test



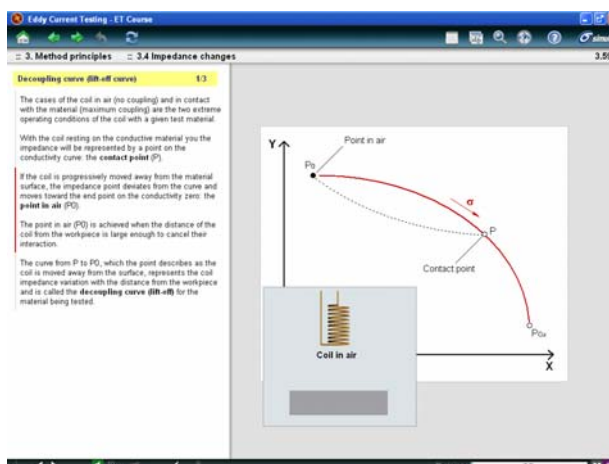
### 2. BASIC PHYSICAL PRINCIPLES

- 2.1 Electricity
- 2.2 Magnetism
- 2.3 Electromagnetism
- 2.4 Measurement units
- Self-evaluation Test



### 3. METHOD PRINCIPLES

- 3.1 Eddy current method
- 3.2 Eddy current properties
- 3.3 Factors affecting the eddy current
- 3.4 Impedance changes
- 3.5 Impedance diagrams
- Self-evaluation Test



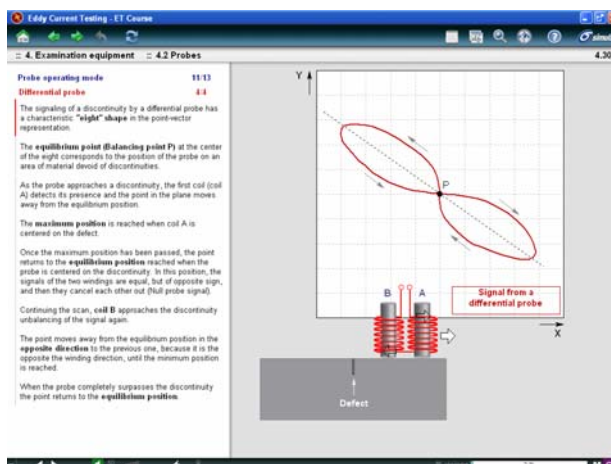
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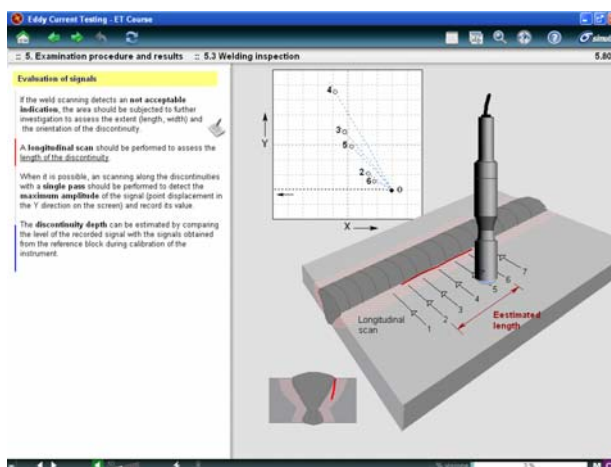
#### 4. EXAMINATION EQUIPMENT

- 4.1 Examination system
- 4.2 Probes
- 4.3 Instruments
- 4.4 Reference standards
- Self-evaluation Test



#### 5. EXAMINATION PROCEDURE AND RESULTS

- 5.1 General examination
- 5.2 Surface inspections
- 5.3 Welding inspection
- 5.4 Tube inspections with an internal probe
- 5.5 Tube and bar inspections with an external probe
- 5.6 Measuring thickness
- 5.7 Measuring conductivity
- Self-evaluation Test



#### FINAL TEST

#### NORMS

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## EDDY CURRENT TESTING: DETAILED CONTENTS

### 1. METALLURGY OF STEEL ([>> ET](#))

#### 1.1 Steel

- Introduction
- Components
- Solidification
- Iron-Carbon Diagram

#### 1.3 Production of Carbon Steels

- Manufacturing Process
- Classification of Products
  - Forged Pieces
  - Castings
  - Rolled Plates
  - Pipes
  - Welded Joints

#### 1.2 Heat Treatments

- Introduction
- Annealing
- Normalization

#### 1.4 Study of Defects

- Discontinuities in Steel
- Discontinuities in Forged Pieces
- Discontinuities in Castings
- Discontinuities in Rolled Plates
- Discontinuities in Pipes
- Discontinuities in Welded Joints

#### 1.5 Self-evaluation Test

- Steel
- Heat Treatments
- Production of Carbon Steels
- Study of Defects

### 2. BASIC PHYSICAL PRINCIPLES ([>> ET](#))

#### 2.1 Electricity

1. Electric charge
2. Electric field
  - Work of the electric field
  - Electric potential energy
  - Electric potential
  - Potential difference
3. Electric current
  - Intensity and direction of the current
  - Electric current density
4. Electromotive force
5. Electrical resistance
  - Resistivity and conductivity
  - Resistivity and temperature
6. Direct current
  - Ohm's Law
7. Alternating current
  - Alternating current parameters
  - Skin effect
  - Vector representation
8. Electric power
9. Thermal effect of the current (Joule effect)

#### 2.2 Magnetism

1. Magnets
2. Magnetic Field
3. Ferromagnetism
4. Magnetic Induction
  - Magnetic permeability
  - Normal magnetization curve
5. Magnetic Hysteresis Loop
6. Magnetic Flux
  - Conservation of magnetic flux

## 2.3 Electromagnetism

1. Magnetic field produced by current
  - Rectilinear Conductor
  - Circular loop
  - Coil
  - Solenoid
  - Toroidal coil
2. Magnetic circuits
  - Hopkinson's law
  - Analogies with electrical circuits
3. Electromagnetic induction
  - Faraday's law of induction
  - Eddy Current or Induced current
  - Lenz's law
  - AC voltage generator (Alternator)
4. Self-induction
  - Self-induced electromotive force
  - Coefficient of self-induction (or inductance)
  - Inductive circuit
5. Mutual induction
  - Coefficient of mutual inductance
  - Coupling coefficient
6. Alternating current circuits
  - Purely resistive circuit (Ohmic circuit)
  - Purely inductive circuit (L circuit)
  - Resistor - Inductor circuit (RL circuit)

## 2.4 Measurement units

1. Electromagnetic quantities
2. Base Units
3. Derived units

## 3. METHOD PRINCIPLES ([>>> ET](#))

### 3.1 Eddy current method

1. General description
2. Typical applications
3. Advantages
4. Limitations

### 3.2 Eddy current properties

1. Introduction
2. Eddy currents paths
  - Surface coil (surface probe)
  - Encircling coil
  - Inside diameter coil
3. Penetration depth
  - Standard penetration depth
  - Calculation of standard depth
  - Eddy currents densities
  - Frequency dependence
  - Penetration curves
  - Effective penetration depth
4. Phase shift with depth
  - Calculating phase angle
5. Calculation expressions

### 3.3 Factors affecting the eddy current

1. Introduction
2. Material properties
  - Conductivity of the material
  - IACS system
  - Magnetic permeability
3. Part geometry
  - Thickness of the workpiece
  - Surface shape
4. Presence of discontinuities
  - Shape and orientation of discontinuities
  - Depth of discontinuity
5. Eddy current coupling
  - Lift-off
  - Fill factor
6. Supply frequency of the coil
7. Edge effect

### 3.5 Impedance diagrams

1. Normalized impedance
2. Normalized frequency
3. Diagram: coil on surface
  - Influence of normalized parameters
4. Diagram: external coil with bar
  - Influence of normalized parameters
5. Diagram: external coil with tube
  - Influence of normalized parameters

### 3.4 Impedance changes

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2. Coil impedance
3. Impedance plane
4. Conductivity curve
5. Decoupling curve (lift-off curve)
6. Frequency effects
7. Material thickness effect
8. Non-conductive coating
9. Conductive coating
10. Discontinuity signals
11. Effect of magnetic permeability

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### 4.1 Examination system

1. Parts of the system
2. Eddy current probe
3. Eddy current instrument

### 4.2 Probes

1. Probe classification
2. Coils configuration
  - Encircling probe
  - Internal probe
  - Surface probe
  - Probes with ferrite core
  - Shielded probes
3. Probe operating mode
  - Single coil probe
  - Reflection probe
  - Absolute probe
  - Differential probe
  - Transmission probe
  - Induction bridge
4. Structure of the coil
  - Calculation inductance

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### 4.3 Instruments

1. Instruments of exam
2. Oscillator
3. Measuring circuit
  - Bridge measuring circuit
  - Maxwell-Wien bridge
  - Measuring with absolute probes
  - Measuring with compensated probes
  - Measuring with differential probes
  - Measuring with reflection probes
4. Phase analysis
5. Phase rotation
6. Band-pass filters
  - Frequency response
  - Types of filters
  - Effect of the filters on the signal
7. Display device
  - Digital displays
  - Settings
8. Eddy current instruments
  - Meters instruments
  - Portable instruments
  - Multi-frequency instrument

### 4.4 Reference standards

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2. Conductivity samples
3. Calibration reference standards
  - Samples with natural discontinuities
  - Samples with artificial discontinuities
4. Lift-off samples

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### 5.1 General examination

1. Introduction
2. Sensitivity to defects
  - Lift-off
  - Penetration depth
  - Coil parameters
3. Signal phase discrimination
4. Frequency selection
5. Defect effects on the signal
  - Defect orientation
  - Minimum defect length
  - Defect depth
6. Effectiveness of test
  - Lift-off variations
  - Surface conditions
  - Surface coating
  - Test piece temperature
  - Test piece geometry
  - Probe orientation
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  - Scanning speed

### 5.2 Surface inspections

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2. Examination system
  - Instrument
  - Probes
  - Calibration block
3. Equipment calibration
  - Check sensitivity
  - Calibration procedure
  - Phase adjustment
  - Gain settings
4. Inspection technique
5. Evaluation of signals
6. Sub-surface discontinuities



7. Equipment
8. Reference blocks
9. Testing of ferromagnetic materials

### 5.3 Welding inspection

1. Introduction
2. Examination system
  - Instrument
  - Probes
  - Calibration block
3. Equipment calibration
  - Check sensitivity
  - Phase adjustment
  - Gain settings
  - Coating thickness measurement
  - Coating thickness compensation
4. Inspection technique
  - a) Inspection of the HAZ and parent metal
  - b) Inspection of the welded surface
5. Evaluation of signals
6. Other examination techniques

### 5.5 Tube and bar inspections with an external probe

1. Inspection technique
  - Inspection with encircling coil
  - Inspection with surface probe & rotating workpiece
  - Inspection with surface probe for sectors
2. Calibration reference standards
  - Example of block reference
3. Equipment calibration
4. Inspection method
5. Evaluation of signals

### 5.7 Measuring conductivity

1. Conductivity measuring
  - Factors affecting the measures
2. Instruments
3. Conductivity meters
  - Instrument calibration
  - Measurement execution
4. Measurement by general purpose meters
  - Instrument calibration
  - Choice of operating frequency

### 5.4 Tube inspections with an internal probe

1. Introduction
  - Tube bundle heat exchangers
2. Examination system
  - Instrument
  - Internal probes
  - Calibration reference standards
3. Equipment calibration
  - Differential bobbin coil
  - Absolute bobbin coil
4. Inspection technique
5. Evaluation of signals
  - Estimate depth of discontinuities
6. Ferromagnetic tubes

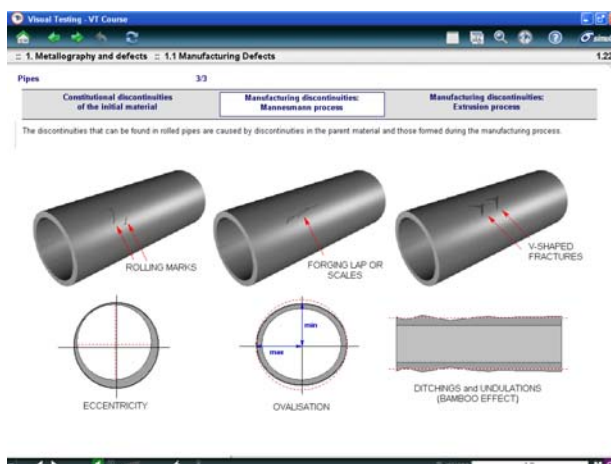
### 5.6 Measuring thickness

1. Measurable thicknesses
2. Thickness of non-conductive coatings
  - Factors affecting the measurement
  - Instruments
  - Calibration reference standards
  - Instrument calibration
  - Thickness measurement
3. Thickness of conductive coatings
  - Factors influencing the measurement
  - Instrument and calibration reference blocks
  - Instrument calibration
  - Thickness measurement
4. Thickness of thin metal sheet
  - Thickness curves
  - Construction of thickness curves

## VT - VISUAL TESTING

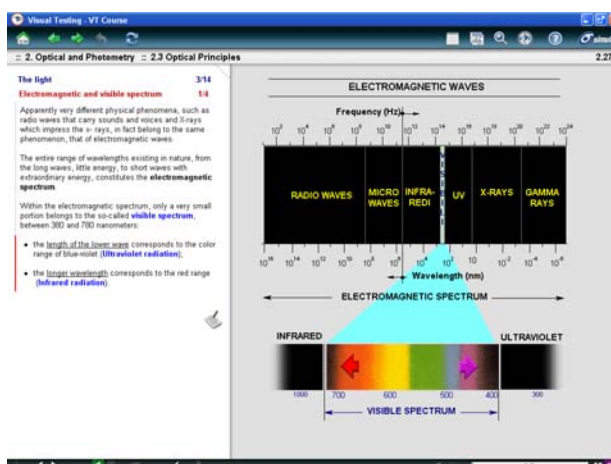
### 1. METALLOGRAPHY and DEFECTS

- 1.1 Manufacturing Defects
- 1.2 Welding Defects
- 1.3 Service Induced Defects
- 1.4 Metallography
- Self-evaluation Test



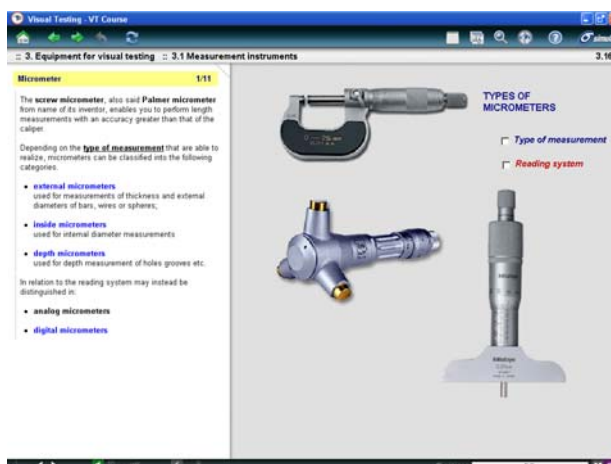
### 2. OPTICAL and PHOTOMETRY

- 2.1 Physiology of Vision
- 2.2 Optical Principles
- 2.3 Photometry
- Self-evaluation Test



### 3. EQUIPMENT and TOOLS

- 3.1 Measuring Instruments
- 3.2 Temperature Indicators
- 3.3 Vision Aids Tools
- 3.4 Endoscopes
- 3.5 Other Systems
- Self-evaluation Test



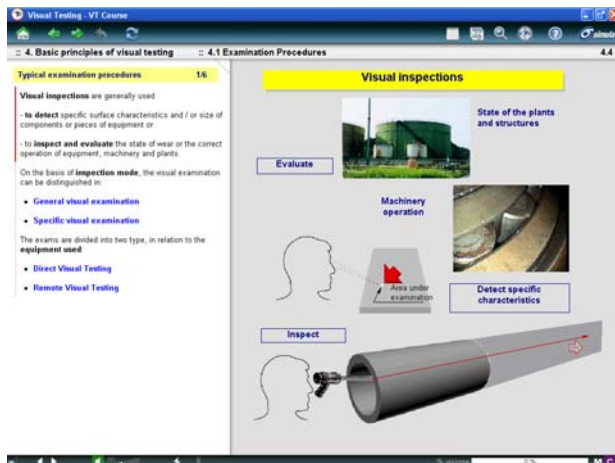
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## 4. BASIC PRINCIPLES

- 4.1 Examination Procedures
- 4.2 Basic Principles of Examination
- 4.3 Safety Aspect
- Self-evaluation Test



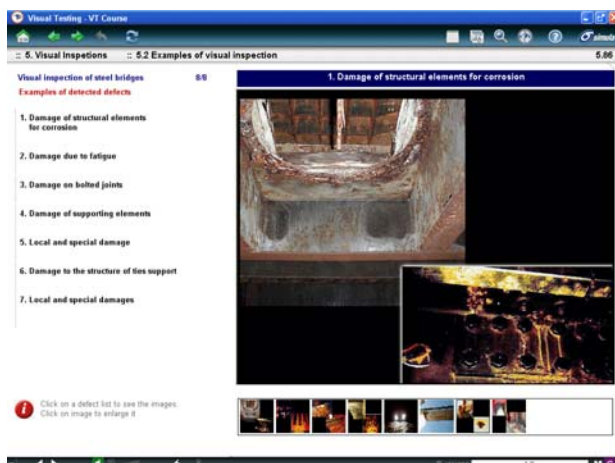
## 5. VISUAL INSPECTIONS

- 5.1 Visual Inspection of steel products
- 5.2 Visual Inspection of welded joints
- 5.3 Visual Inspection of connection elements
- 5.4 Visual inspection of tubes
- 5.5 Visual Inspection of valves
- 5.6 Visual Inspection of pumps
- Self-evaluation Test



## 6. EXAMPLES OF VISUAL INSPECTION

- 6.1 Inspection in automotive industry
- 6.2 Inspection of oil tanks
- 6.3 Visual inspection of steel bridges
- 6.4 Automotive industry
- 6.5 Power Generation and plant
- 6.6 Aerospace
- 6.7 Building and Construction



## FINAL TEST

## NORMS

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## VISUAL TESTING: DETAILED CONTENTS

### 1. METALLOGRAPHY and DEFECTS ([>> VT](#))

#### 1.1 Manufacturing Defects

- Production of Steels
- Defects in steel production
- Forging (and pressing)
- Castings
- Pipes
- Extruded
- Wire drawing
- Thermomechanical processing

#### 1.2 Welding Defects

- Welded joints
- Welding symbols
- Defects in Welded Joints

#### 1.3 Service Induced Defects

- Introduction
- Cracks in operation
- Loss of material
- Deformations

#### 1.4 Metallography

- Metallographic sample
- Metallographic techniques

#### 1.5 Self-evaluation Test

- Manufacturing Defects
- Welding Discontinuities
- Service Defects
- Metallography

### 2. OPTICAL and PHOTOMETRY ([>> VT](#))

#### 2.1 Physiology of Vision

- The vision
- Tests of visual acuity
- Parameters of vision
- Human eye sensitivity
- Visual defects

#### 2.2 Optical Principles

- The light
- Fundamental laws of optics
- Focusing and Scattering
- Defects and limits of instruments

#### 2.3 Photometry

- Light sources
- Propagation and light measurement
- Measurement of lighting quantity
- Sensors for photometry
- Artificial lighting

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### 3. EQUIPMENT and TOOLS ([>> VT](#))

#### 3.1 Measuring Instruments

- Introduction
- Graduated metal ruler
- Goniometers
- Calipers
- Micrometer
- Test Indicators
- Welding gauge
- Other measuring tools

#### 3.2 Temperature Indicators

- Temperature measurement
- Types of thermometers

#### 3.3 Vision Aids Tools

- Magnifier system
- Special optical systems
- Mirrors
- Stroboscope

#### 3.4 Endoscopes

- Endoscopy
- Measurement methods
- Application fields

#### 3.5 Other Systems

- Closed-circuit television systems
- Computerized systems
- Image processing systems
- Automated Visual Inspection
- Robotic systems

### 4. BASIC PRINCIPLES ([>> VT](#))

#### 4.1 Examination Procedures

- Introduction
- Typical examination procedures
- Evaluation and documentation
- Standards

#### 4.2 Basic Principles of Examination

- Introduction
- Inspector of visual testing
- Object to be examined
- Optical Equipment
- Lighting for visual examination
- Examination recording

#### 4.3 Safety Aspect

- Introduction
- Danger from light sources
- Risk assessment
- Recommendations and Protection means

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## 5. VISUAL INSPECTIONS ([>> VT](#))

### 5.1 Visual Inspections

- Visual Inspection of steel products
- Visual Inspection of welded joints
- Visual Inspection of connection elements
- Visual inspection of tubes
- Visual Inspection of valves
- Visual Inspection of pumps

### 5.2 Examples of Visual Inspections

- Inspection in automotive industry
- Inspection of oil tanks
- Visual inspection of steel bridges
- Automotive industry
- Power Generation and plant
- Aerospace
- Building and Construction

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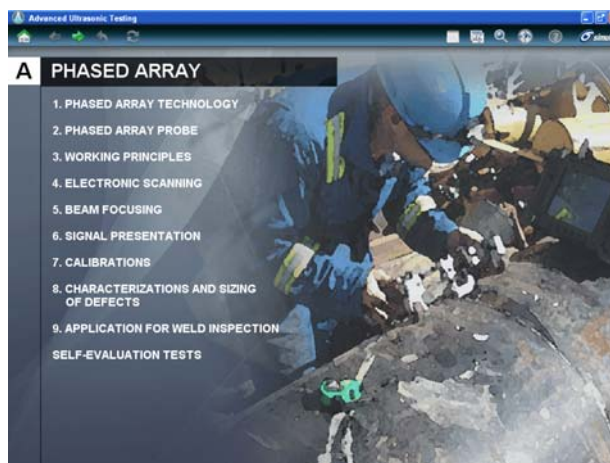
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## AUT - AUTOMATED ULTRASONIC TESTING (Phased Array & TOFD)

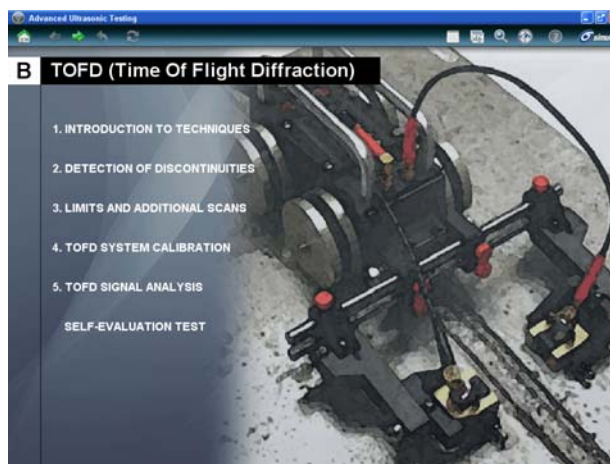
### 1. PHASED ARRAY

- 1.1 Phased array technology
- 1.2 Phased array probe
- 1.3 Working principles
- 1.4 Electronic scanning
- 1.5 Beam focusing
- 1.6 Signal presentation
- 1.7 Calibrations
- 1.8 Characterizations of defects
- 1.9 Application for weld inspection
- Self-evaluation tests
- **SimSCAN**



### 2. TOFD

- 2.1 Introduction to techniques
- 2.2 Detection of discontinuities
- 2.3 Limits and additional scans
- 2.4 TOFD system calibration
- 2.5 TOFD signal analysis
- Self-evaluation test
- **TOFD Images**



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## **AUTOMATED ULTRASONIC TESTING: DETAILED INDEX**

### **1. PHASED ARRAY (>> PA)**

#### **1.1 Phased array technology**

- Introduction
- Phased Array transducer
- Ultrasound beamforming
- Beam steering
- Beam focusing
- Electronic scanning
- Signal imaging
- Advantages and disadvantages
- Summary

#### **1.2 Phased array probe**

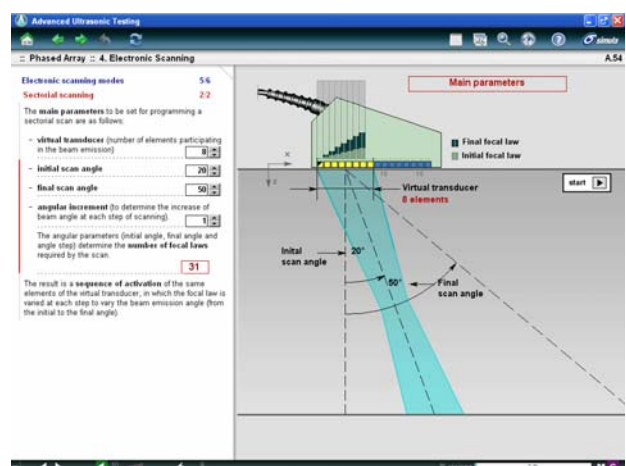
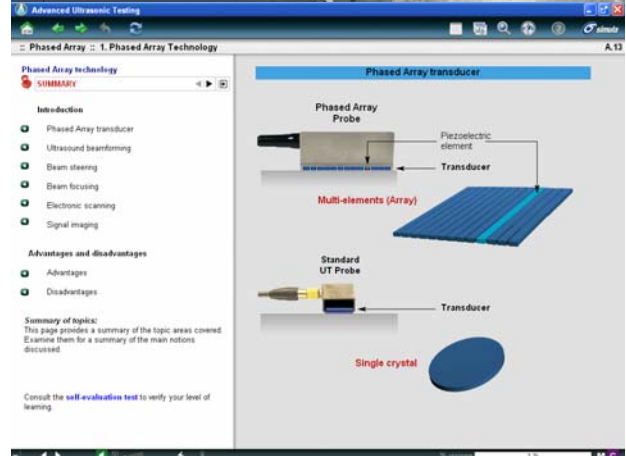
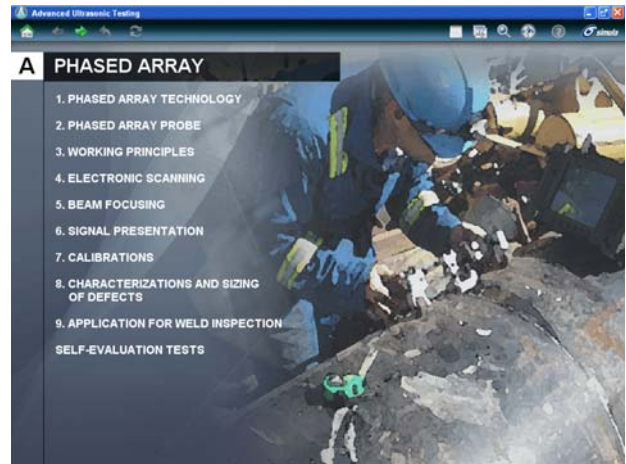
- Probe structure
- Transducer
  - Transducer shape
  - Dimensional parameters
  - Wedge and types of waves
- Wedge-shaped base
  - Zero-degree wedge (Plates)
  - Wedge for complex shapes
- Summary

#### **1.3 Working principles**

- Beam forming
- Beam steering
  - Virtual transducer
  - Focal laws
  - Straight beam: Constant focal law
  - Angled beam: Linear focal law
  - Focused beam: Quadratic focal law
  - Angled and focused beam
- Acquisition cycles
  - Emitting
  - Receiving
- Summary

#### **1.4 Electronic scanning**

- Electronic beam steering
- Electronic scanning modes
  - Fixed angle scanning
  - Sectorial scanning
  - Combination of base scans
  - Multichannel mode

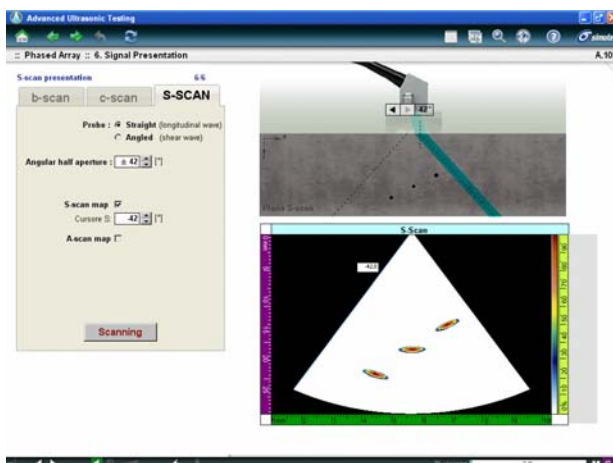




- Summary

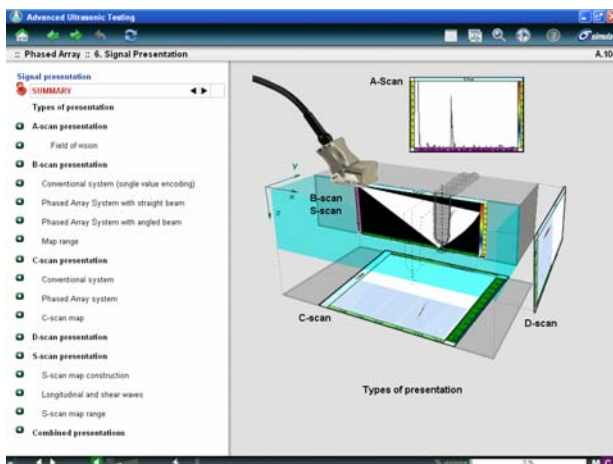
### 1.5 Beam focusing

- Focusing control
  - Constant focal distance
  - Changing the focal distance
- Focusing modes
  - Constant focal distance
  - Changing the focal distance
- Dynamic focusing
- Spatial resolution
  - Spatial resolution
  - Lateral resolution
  - Elevation resolution
- Probe resolution and characteristics
  - Probe frequency
  - Virtual aperture of the transducer
  - Virtual aperture and lobes
  - Summarizing table
- Summary



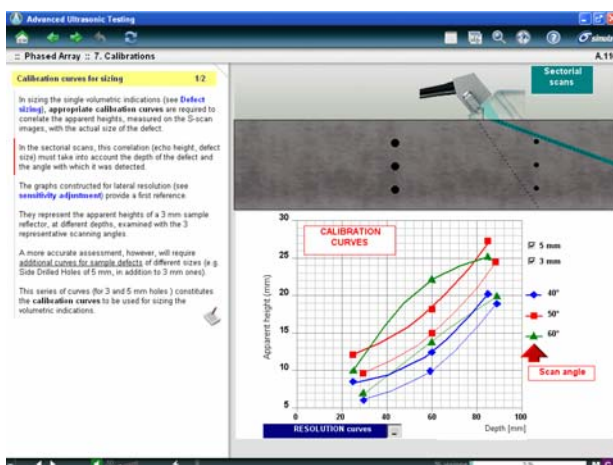
### 1.6 Signal presentation

- Types of presentation
- A-scan presentation
- B-scan presentation
- C-scan presentation
- D-scan presentation
- S-scan presentation
- Combined presentations
- Summary



### 1.7 Calibrations

- Introduction
- Calibration block
- Sensitivity adjustment
- Construction of DAC curves
- Determining the lateral resolutions
- Calibration curves for sizing
- Summary
- Standard reference



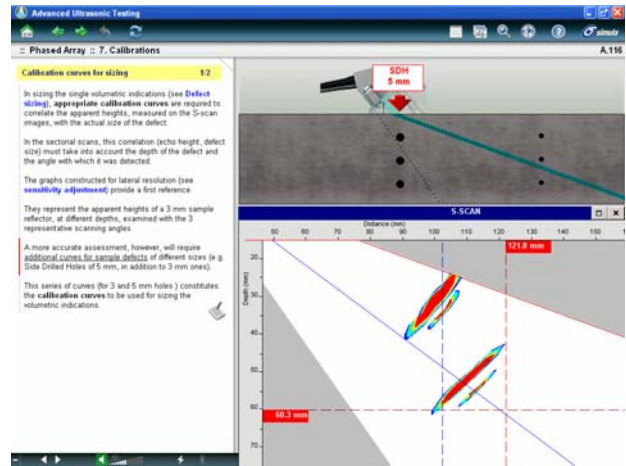
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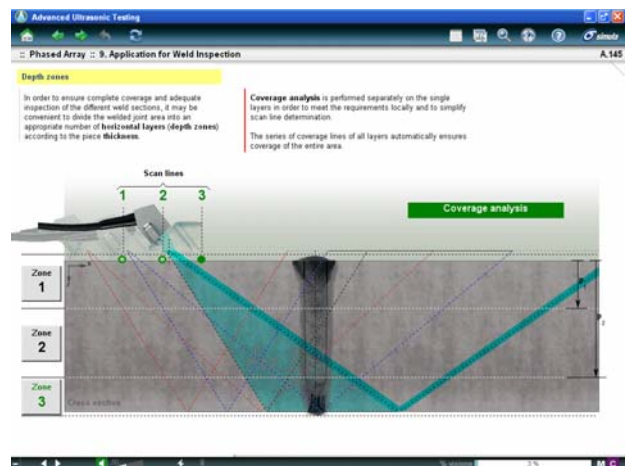
## 1.8 Characterizations of defects

- Introduction
- Types of defects
- Defect sizing
- Defect position
- Summary



## 1.9 Application for weld inspection

- Inspection with Phased Array
- Probe movement
- Scan lines
- Depth zones
- Multi-channel mode (virtual probe)
- Gate setting
- Focusing for welding
- Inspection speed
- Scan plan
- Summary



## Self-evaluation Test

- Phased Array technology
- Phased Array probe
- Working principles
- Electronic scanning
- Beam focusing
- Signal presentation
- Calibrations
- Characterisations of defects

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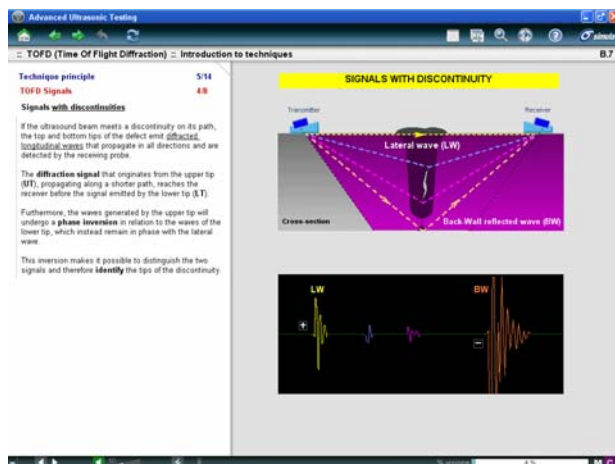
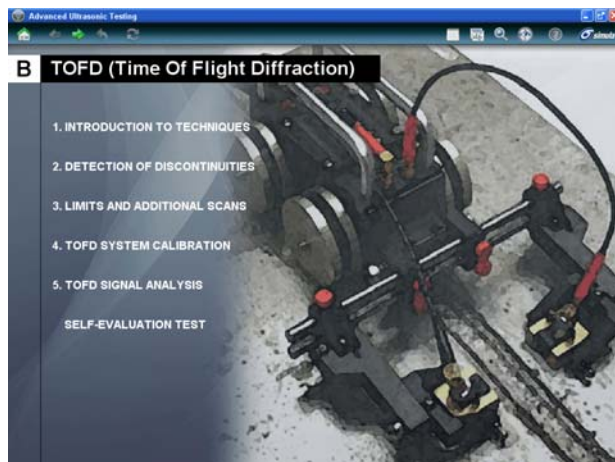
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## 2. TOFD (Time Of Flight Diffraction) (>> TOFD)

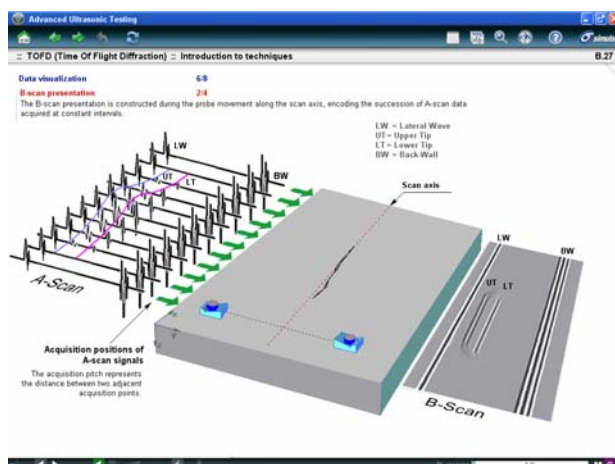
### 2.1 Introduction to techniques

- Technique principle
  - TOFD Signals
  - Types of waves and signals produced
  - Sizing a discontinuity
  - Scan zones and dead zones
  - Suitable scan materials
 Summary
  
- Advantages and disadvantages of TOFD
  - Advantages of TOFD
  - Disadvantages of TOFD
 Summary
  
- Data visualization
  - A-scan presentation
  - B-scan presentation
 Summary



### 2.2 Detection of discontinuities

- Defect inspection
  - Scan types
  - Non-parallel scan
  - Parallel scan
  - Combined scans
 Summary
  
- Defect characterisation
  - Phase relationships between signals
  - Types of discontinuity
 Summary
  
- Defect sizing
  - Depth calculation
  - Height calculation
  - Measuring time of flight
  - Calculation time of flight
 Summary



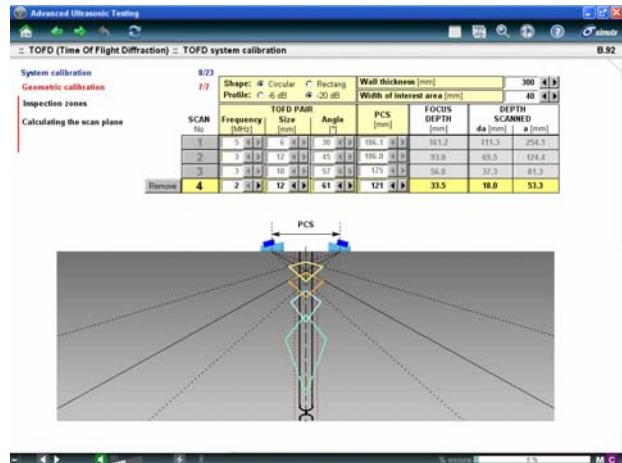
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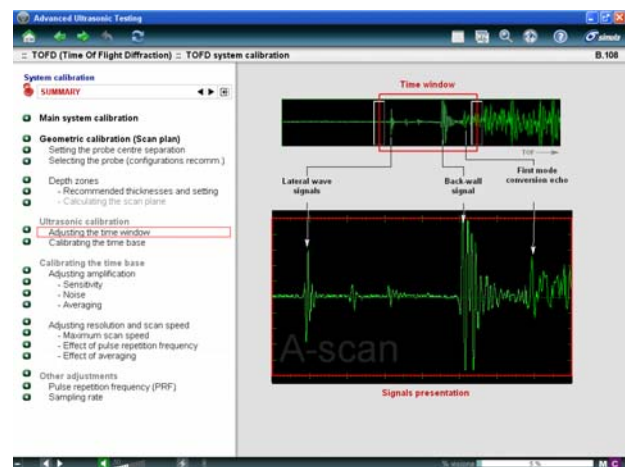
### 2.3 Limits and additional scans

- Limitations of the technique
    - Locating accuracy
    - Calculation error in locating
    - Spatial resolution
    - Dead zones
    - Calculating spatial resolution and dead zone
  - Additional scans
    - Scans with different frequencies
    - Scans with different emission angles
    - Scans with offset distances
- Summary



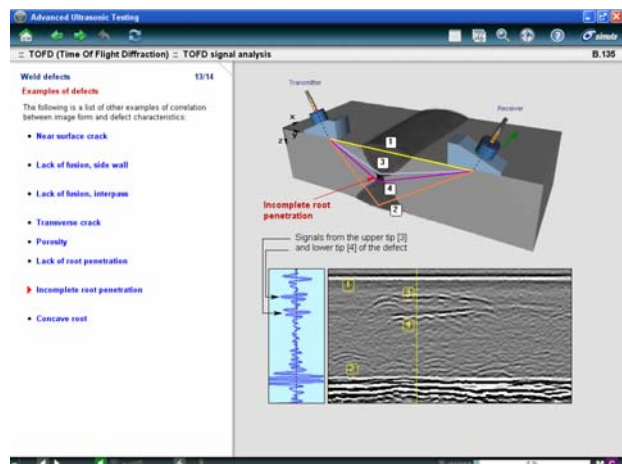
### 2.4 TOFD system calibration

- TOFD system structure
  - Operation and characteristics
  - Ultrasound probes
- System calibration
  - Geometric calibration
  - Ultrasonic calibration
  - Calibrating the acquisition system
  - Other adjustments
- Reference blocks
- Image quality
  - Basic requirements of TOFD image
  - TOFD image anomalies
- Summary



### 2.5 TOFD signal analysis

- Introduction
  - Weld defects
    - Examples of defects
  - Sizing defects
    - Measuring depth and height
    - Measuring length
    - Examples of sizing
  - TOFD references
- Summary



### Self-evaluation Test

- Introduction to techniques
- Detection of discontinuities
- Limits and additional scans
- TOFD system calibration
- TOFD signal analysis

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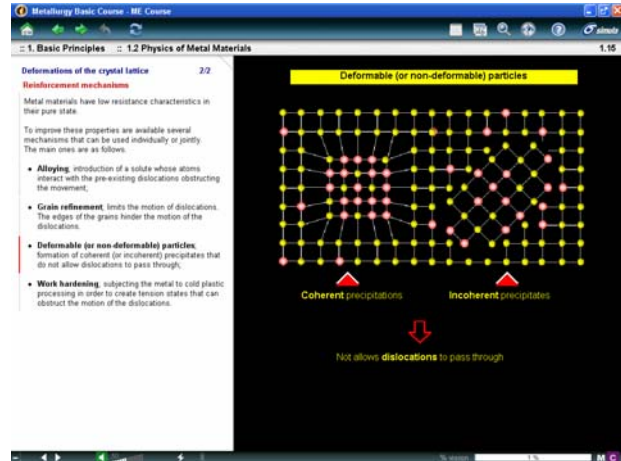
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# ME - METALLURGY BASIC COURSE

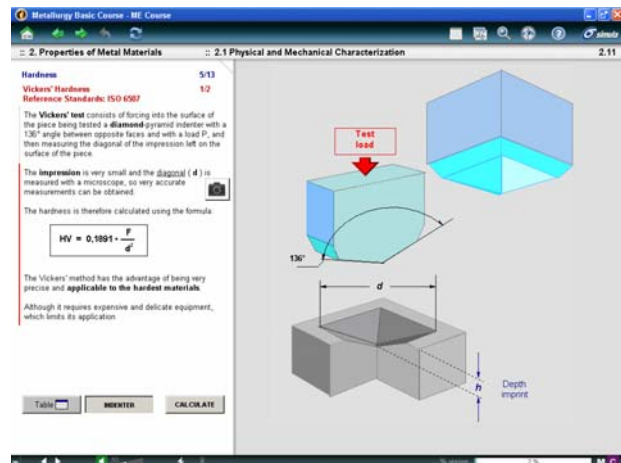
## 1. BASIC PRINCIPLES

- 1.1 Chemical Systems
- 1.2 Physics of Metal Materials
- 1.3 Phase Diagram
- 1.4 Phase Diagram of Binary Metal Alloys
- 1.5 Process Metallurgy
- 1.6 Heat Treatments
- Self-evaluation Tests



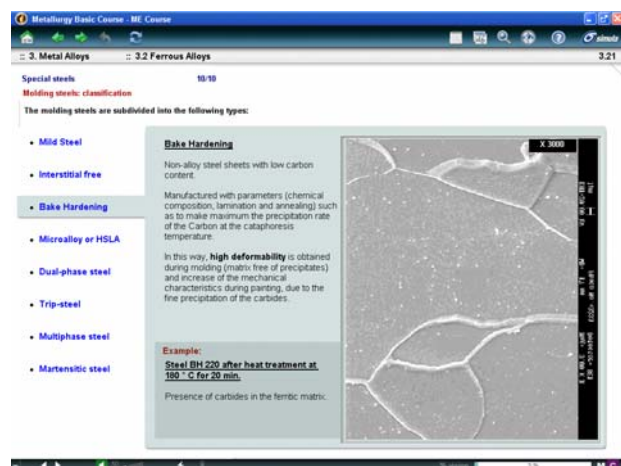
## 2. PROPERTIES OF METAL MATERIALS

- 2.1 Physical and mechanical characterization
- 2.2 Sample preparation
- 2.3 Test procedures and reference standards
- 2.4 Test results and suitability for use
- Self-evaluation Tests



## 3. METAL ALLOYS

- 3.1 Introduction
- 3.2 Ferrous Alloys
- 3.3 Non-Ferrous Alloys
- Self-evaluation Tests



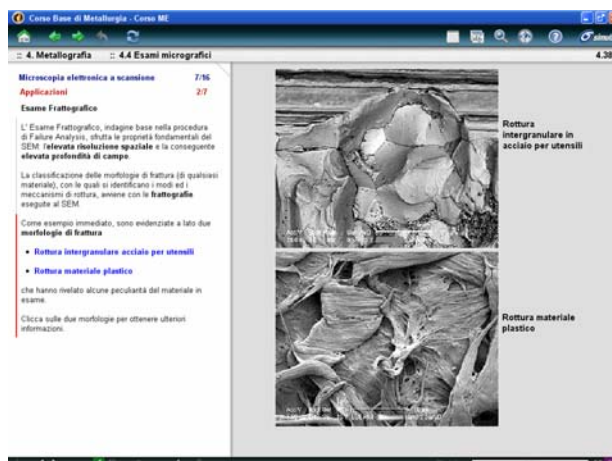
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## 4. METALLOGRAPHY

- 4.1 Metallographic Techniques
  - 4.2 Sample Preparation
  - 4.3 Preparation Techniques
  - 4.4 Micrographic Examinations
  - 4.5 Characteristic Structures of Ferrous Materials
  - 4.6 Test Procedures and Reference Standards
  - 4.7 Test Results and Suitability for Use of Materials
  - 4.8 Non-destructive Testing
- 
- Self-evaluation Tests



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## METALLURGY BASIC COURSE: DETAILED INDEX

### **1. BASIC PRINCIPLES** ([>> ME](#))

#### **1.1 Chemical Systems**

- Homogeneous and heterogeneous systems
- Chemical-physics of metallurgical processes

#### **1.2 Physics of Metal Materials**

- Structure of matter
- Solidification metals and alloys
- Crystal lattices
- Solid solutions
- Deformations of the crystal lattice
- Solid state transformations

#### **1.3 Phase Diagram**

- Cooling curve of a pure metal
- Solubility in the liquid state
- Insolubility in the solid state

#### **1.4 Phase Diagram of Binary Metal Alloys**

- General rules of interpretation
- Iron-Carbon Diagram
  - Hypoeutectoid steel
  - Hypereutectoid steel
  - Eutectoid steel
  - Hypoeutectic cast iron
  - Hypereutectic cast iron
  - Structural transformations
  - Critical points
- Addition of Elements

#### **1.5 Process Metallurgy**

- Metallurgical processes
- Production of Carbon Steels
  - Production of Cast Iron
  - Refining
  - Casting and Solidification
  - Rolling

#### **1.6 Heat Treatments**

- Introduction
  - Heat treatment steps
  - Critical points
  - Thermal transformations
  - Cooling rate
  - TTT and CCT Curve (or Bain curve)
  - Steel hardenability
- Kinetics transformation of the steel structure
  - Austenite
  - Ferrite

- Perlite
- Cementite
- Bainite
- Martensite
- Type of thermal treatments
- Heat treatments at temperatures above critical points
  - Full Annealing
  - Isothermal annealing
  - Coalescence annealing
  - Normalisation
  - Quenching
- Treatments without phase variations
  - Tempering
  - Softening annealing
  - Relaxation
- Quench and tempering
- Surface heat treatments
  - Induction hardening
  - Thermochemical diffusion treatments
  - Cementation
  - Nitriding
  - Comparison Cementation-Nitriding

### Self-evaluation Tests

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## 2. PROPERTIES OF METAL MATERIALS ([>> ME](#))

### 2.1 Physical and mechanical characterization

- Mechanical properties
- Tensile strength
- Hardness
  - Brinell Hardness
  - Vickers Hardness
  - Rockwell Hardness
  - Microhardness
- Resiliency
  - Test equipment
  - Transition ductile-brittle
  - Transition temperature
  - Resilience test
  - Test parameters
  - Izod impact strength test
- Creep (Cold flow)
- Fatigue resistance
  - Fatigue failures
  - Typical aspect of a fatigue fracture
  - Fatigue tests
  - Wohler's curve
  - Fatigue limit
- Surface roughness
  - Roughness parameters
  - Roughness measurement

### 2.2 Sample preparation

- Sampling for mechanical tests
  - Definitions
  - Preparation and identification of the samples
- Location and preparation of samples
  - Flat products
  - Long products
  - Tubes

### 2.3 Test procedures and reference standards

- Test procedures and standards
- Test standards
- Measurement uncertainty
  - Possible factors of uncertainty
  - Types of measurement uncertainty
  - Expression of measurement uncertainty

### 2.4 Test results and suitability for use

- Use of test results
- Design mechanical parts
  - Mechanical tests
  - Tensile strength
  - Traction stiffness
  - Compressive strength

- Hardness measurement
- Resistance to torsion, bending
- Resistance to shear stresses
- Resistance to crack propagation
- Resistance to fatigue
- Resistance to creep
- Environmental effects on mechanical properties
  - Stress Corrosion Cracking
  - Hydrogen Induced Cracking
  - Corrosion Fatigue
  - Resistance to shock
- Manufacturing process
  - Criticality of the transformation
  - Mechanical properties and transformation
  - Controls and Testing
- Failure Analysis and Life Assessment
  - Life assessment
  - Failure analysis

### Self-evaluation Tests

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### 3. METAL ALLOYS ([>> ME](#))

#### 3.1 Introduction

#### 3.2 Ferrous Alloys

- Steel grades
  - EN designation steels
  - AISI classification
- Classification based on alloy elements
- Classification according to applications
- Structural steels
  - General purpose steel
  - Weldable steels
- Special steels
  - Nitriding steels
  - Cement steels
  - Self tempering steels
  - Tool steels
  - Steels for rolling bearings
  - Spring steels
  - Molding steels
  
- Stainless steels
- Casting steels
- Cast Irons

#### 3.3 Non-Ferrous Alloys

- Aluminum Alloys
  - Characteristic structures
  - Alloy elements and features
  - Influence of alloying elements
  - Aluminum Industrial Alloys
- Magnesium Alloys
- Titanium Alloys
- Copper Alloys
- Nickel Alloys
- Cobalt Alloys

#### Self-evaluation Tests

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## 4. METALLOGRAPHY ([>> ME](#))

### 4.1 Metallographic Techniques

#### 4.2 Sample Preparation

- Metallographic sample
- Basic operations
  - Sectioning or cutting
  - Resin encapsulation
  - Grinding
  - Polishing
  - Chemical etching
- Metallographic replicas

#### 4.3 Preparation Techniques

- Ferrous alloys
- Anti-friction alloys
- Aluminum alloys
- Copper alloys
- Magnesium alloys
- Nickel alloys
- Titanium alloys
- Zinc alloys

#### 4.4 Micrographic Examinations

- Optical microscopy
- Scanning Electron Microscopy
  - Components
  - Operation principle
  - Related technique
  - Metallurgical application
  - Evolution of microscopy techniques
  - Evolution of microanalysis techniques

#### 4.5 Characteristic Structures of Ferrous Materials

- Austenite
- Ferrite
- Cementite
- Pearlite
- Martensite
- Bainite
- Graphite

#### 4.6 Test procedures and reference standards

- Test procedures and standards
- Standardization levels

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#### 4.7 Test results and suitability for Use of Materials

- Use of the test results
- Microstructural examinations
  - Band structure classification in laminates
  - Determining average grain size
  - Determination of inclusions in steel
  - Estimating the depth of decarburization

#### 4.8 Non-destructive Testing

- Introduction
- RT - Radiographic Testing
- UT - Ultrasonic Testing
- MT - Magnetic Testing
- PT - Penetrant Testing
- ET - Eddy current Testing
- VT - Visual Testing
- IT - Infrared Thermography
- CT - Computerized Tomography
- Thermal Stress Analysis

#### Self-evaluation Tests

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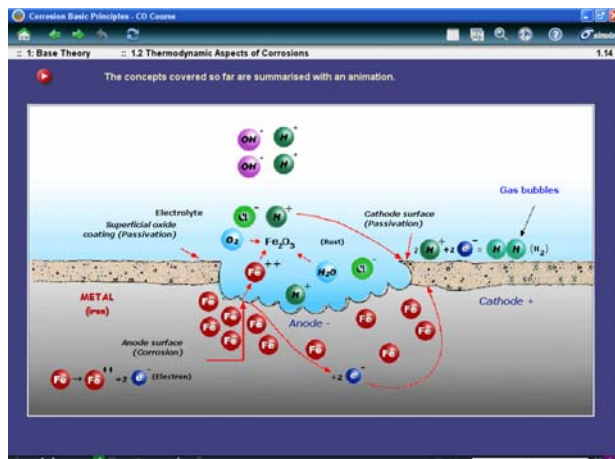
Phone: 913-685-0675, Fax: 913-685-1125  
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## CO - CORROSION BASIC PRINCIPLES

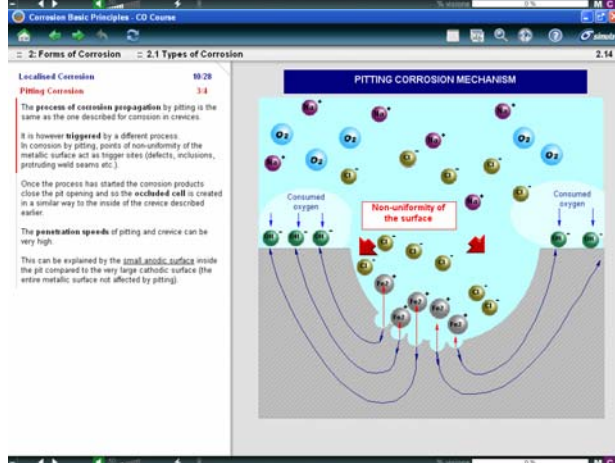
### 1. BASE THEORY

- 1.1 Introduction
- 1.2 Thermodynamic Aspects
- 1.3 Kinetics Principles
- 1.4 Examples of Corrosion Cells in the Pipeline
- 1.5 Internal Corrosion Parameters
- 1.6 Corrosive Environments
- Self-evaluation Test



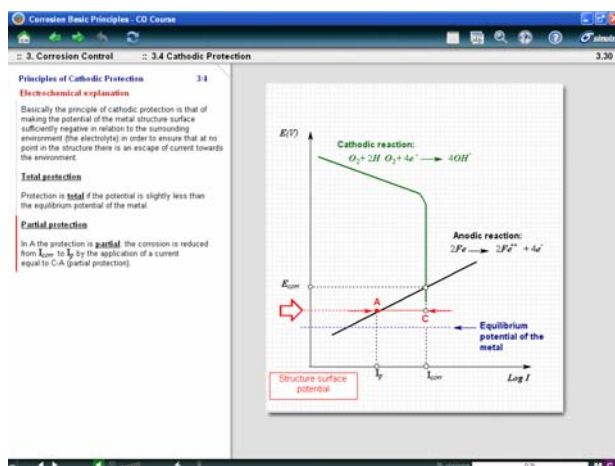
### 2. FORMS OF CORROSION

- 2.1 Types of Corrosion
- 2.2 Examination of Real Cases
- Self-evaluation Test



### 3. INTRODUCTION TO CORROSION CONTROL

- 3.1 Introduction
- 3.2 Protection from the Internal Corrosion
- 3.3 Passive Protection (Coatings)
- 3.4 Cathodic Protection
- Self-evaluation Test



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## **CORROSION BASIC PRINCIPLES: DETAILED INDEX**

### **1. BASE THEORY ([>> CO](#))**

#### **1.1 Introduction**

- The Corrosive Process
- Direct and Indirect Damage
- Corrosion Classification

#### **1.2 Thermodynamic Aspects**

- Introduction
- Anode
- Cathode
- Metal Conductor
- Electrolyte
- Corrosion Cell
- Electromotive Force
- Corrosion Rate

#### **1.3 Kinetics Principles**

- Polarisation
- Passivity
- Cathodic Characteristic of Oxygen

#### **1.4 Examples of Corrosion Cells in the Pipeline**

- Introduction
- Coupling of Different Materials
- Exposure to Different Soils
- Corrosion by Differentiated Aeration
- Contact Between New and Old Pipe

#### **1.5 Internal Corrosion Parameters**

- Introduction
- Water Wetting Conditions
- Hydrodynamic Conditions
- Water Composition
- Oxygen
- Carbon Dioxide
- Hydrosulphide
- Sulphate-Reducing Bacteria

#### **1.6 Corrosive Environments**

- Corrosion in Sea water
- Corrosion in Soils
- Atmospheric Corrosion

#### **Self-evaluation Test**

### **2. FORMS OF CORROSION ([>> CO](#))**

#### **2.1 Types of Corrosion**

- Introduction
- Uniform Corrosion
- Localised Corrosion
- Galvanic Corrosion
- Crevice Corrosion
- Pitting Corrosion
- Stress Corrosion Cracking (SCC)
- Corrosion Fatigue
- Hydrogen Induced Cracking (HIC)
- Intergranular Corrosion
- Erosion - Corrosion
- Welding and Corrosion

#### **2.2 Examination of Real Cases**

- Uniform Corrosion
- Pitting Corrosion
- Intergranular Corrosion
- Crevice Corrosion
- Stress Corrosion Cracking
- Fatigue and Corrosion fatigue

#### **Self-evaluation Test**

### 3. INTRODUCTION TO CORROSION CONTROL ([>> CO](#))

#### 3.1 Introduction

- The Corrosion Control
- The Aims of Control
- Examples of Control
- Control Methods

#### 3.2 Protection from the Internal Corrosion

- Corrosion inhibitors
- Passivating inhibitors
- Filming inhibitors

#### 3.3 Passive Protection (Coatings)

- Introduction
- Metal Coatings
- Paints
- Thick Organic Coatings
- Coating Properties
- Surface Preparation
- Commercially Available Coatings

#### 3.4 Cathodic Protection

- Principles of Cathodic Protection
- Cathodic Protection Systems
- Activation of the Cathodic Protection

#### Self-evaluation Test

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